JOURNAL

OF THE

BOSTON SOCIETY

OF

CIVIL ENGINEERS

VOLUME 9

1922

CONTENTS AND INDEX

Published monthly, excepting July and August, by the Society,
715 Tremont Temple, Boston, Massachusetts.

NOTE.— This Society is not responsible for any statement made or opinion expressed in its publications.

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

HIGHWAY CONSTRUCTION IN MASSACHUSETTS.

BY ARTHUR W. DEAN,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

(Presented December 21, 1921.)

THIRTY years ago there was an extensive propaganda for better roads, due at that time to the desires of the manufacturer and of the user of bicycles, the one to increase his sales, and the other to increase his enjoyment. To-day the propaganda is by the manufacturer and user of motor vehicles, one for the same reason that formerly inspired the bicycle manufacturer, and the other for far greater reasons, in that where the bicycle was used almost wholly for pleasure the motor vehicle is not only used for pleasure but is one of the prime commercial requisites of the present day.

The first states to be effectively influenced by the bicycle propaganda were Massachusetts, Connecticut and New Jersey. The first legislation in Massachusetts leading toward state activities in road construction was in 1892, when the legislature passed an Act which did not authorize any construction, but provided for investigation and recommendation by a Commission. Ten thousand dollars was made available for this purpose. The first real constructive Act was in 1894, in which year the state appropriated $300 000. This, at the time, was considered by many as an extravagance on the part of the state,

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and little did they foresee at that time that in 1921 there would be state funds available in the Commonwealth for highway expenditure amounting to very nearly $8 000 000.

The rapid increase in the appropriations and in the progress in road building under state supervision may be attributed almost wholly to the motor vehicle, and a few statistics are here given in order to show the necessity for the expenditures of large sums of money in the improvement of the highways.

Motor vehicles first became sufficiently numerous to require regulation and registration in the year 1907, and in the following year motor vehicles were first registered in Massachusetts. Very few of the states at that time required registration, hence statistics as to the number of motor vehicles using the highways in the United States that year are not available. In 1920, according to a table prepared by the Bureau of Public Roads in Washington, there were approximately 9 000 000 cars registered in the United States, that being 83 per cent. of all motor cars in the world. This number of cars indicates one car for each 11 persons in the United States, or 3.8 cars for each mile of highway. In the same year, 1920, there were registered in Massachusetts 274 498 motor vehicles, being one vehicle for each 11 persons and 12 vehicles for each mile of public way.

There is, at the present time, strong agitation by those interested in securing funds for highway construction and maintenance, to place upon the owners and users of motor vehicles a greater responsibility or liability for payment of the expense of construction and maintenance of our highways. By some people the principal advocates of increased registration fees are considered as carrying on the agitation for political rather than business reasons, but the above figures should indicate that funds must be secured from some source, the possible available sources being (1) direct taxation, (2) bond issue, (3) fees from users of motor vehicles.

If the state is to progress in its road-building program one or all of the above sources must be utilized, and as the users of the motor vehicles derive the immediate benefit, it is quite natural and fair that the users should bear their fair portion of the road expense.

Massachusetts began raising funds by the issuance of thirty-year bonds. This policy was pursued until the year 1913, in which year, and for four succeeding years, fifteen-year serial bonds were issued. Beginning in 1919, however, the Commonwealth ceased issuing bonds for highway purposes, and money was raised from ordinary revenue.

The total amount of bonds issued by the Commonwealth to November 30, 1921, for state highways and "small town" construction was $11 767 000. The amount outstanding on the above date was $6 745 500. A sinking fund, however, established when the bonds were issued, brings the net debt down to about $3 000 000.

The change in the type of vehicles using the road has been followed in natural sequence by the necessity for change in the type of construction. The original adopted types of state highway were the water-bound macadam for the principal roads and gravel for secondary roads.

About 1907 it became evident that the water-bound macadam road or the gravel road would not withstand motor vehicle traffic. For a short time it appeared that the use of a light coating of oil or tar on the surface would preserve the road, but as motor vehicles increased it became more evident that the type of surface must be changed.

Various experiments were made with tar, asphalt and other materials, and the so-called bituminous macadam road was evolved and has been satisfactorily used up to the present time, where it has been built with suitable foundation. This type of surface pavement can best be described by taking verbatim the specifications of the State Department of Public Works, which are as follows:

"The base course shall consist of broken local or trap stone spread and rolled on the sub-grade prepared as hereinbefore specified.

"The width of the base course shall be eighteen (18) feet except on banked curves, where the width shall be twenty-one (21) feet, and the depth shall be four (4) inches, unless otherwise specified, after rolling with a steam roller weighing not less than ten (10) tons.

"The broken stone for the base course shall consist of clean, durable, crushed rock having a French coefficient of wear of not less than 8, and shall consist of No. 1 and No. 2 stone. The No. 1 stone shall consist of stone that will pass through a ring two and one-half (2½) inches in diameter and will not pass through a ring one and one-quarter (1¼) inches in diameter.

"The No. 2 stone shall consist of stone that will pass through a ring one and one-quarter (1¼) inches in diameter, but will not pass through a ring one-half (½) inch in diameter.

"The proportion of No. 1 and No. 2 stone to be used in the base course shall be as directed by the engineer, the intention being, where stone is crushed locally, to vary the proportions in order to use the output of the crusher.

"The course shall be shaped to a true section conforming to the proposed cross-section of the highway, and when thoroughly rolled shall be two (2) inches below and parallel to the proposed finished surface of the surfacing course.

"Any depressions or irregularities which may occur shall be filled with broken stone, of such sizes as directed by the engineer, and again rolled until the surface is true and unyielding. The interstices in this course shall then be filled with stone screenings, and after being thoroughly rolled the screenings shall be just below the top of the broken stone as directed by the engineer, and no screenings shall be left on top of the stones.

"All broken stone shall be spread from carts by hand, or from a dumping board, or from self-spreading carts which shall be of a type approved by the engineer.

"If so ordered by the engineer the thickness of the broken stone shall be increased or diminished at such points as he may direct.

"The finished surface of the road shall present such a crown as shall be directed by the engineer.

"If local stone or stone not shipped by rail is used it shall be weighed on scales furnished by and at the expense of the contractor. Said scales shall be satisfactory to the engineer, and they shall be sealed at the expense of the contractor as often as the engineer may deem necessary to insure their accuracy.

"A sworn weigher, to be appointed and compensated by the department, shall weigh all the broken stone required to be weighed as above provided.

"If the stone is shipped by rail the car weights may be accepted, but scales shall be used as above provided if the engineer so directs.

"This work shall be paid for at the contract unit price per ton for broken stone rolled complete in place, which price shall include all materials, equipment, tools, labor and work incidental thereto.

"The bituminous macadam surface shall be laid on a 'broken stone base course' constructed as hereinbefore specified.

"The surface course shall be composed of broken, local or trap stone and bituminous material applied by the penetration method, with the bituminous material covered with pea stone.

"The width of the bituminous macadam surface course shall be eighteen (18) feet, except on banked curves, where the width shall be twenty-one (21) feet.

"The broken stone shall conform to the requirements specified for broken stone base course, and shall consisit of No. 1 stone, excepting for covering the bituminous material, for which pea stone shall be used.

"Pea stone shall consist of that portion of the crusher product which will pass a three-quarter (¾) inch screen and will be retained on a quarter inch screen and shall be free from dust.

"Upon the 'broken stone base course,' shall be spread an upper course of No. 1 stone, which shall be two (2) inches in depth after rolling with a steam roller weighing not less than ten (10) tons.

"The upper course shall be shaped to a true section conforming to the proposed cross-section of the highway, and when thoroughly rolled shall conform to the proposed grade and cross-section.

"Any depressions or irregularities which may occur shall be filled with broken stone, of such sizes as directed by the engineer, and again rolled until the surface is true and unyielding.

"Upon the upper course of stone, prepared as hereinbefore described, bituminous material shall be uniformly applied by a pressure machine at the rate of one and three-quarters (1¾) gallons to each square yard of surface and uniformly covered with clean pea stone in sufficient quantity to fill the surface voids and permit the steam roller to pass over it without sticking to the bitumen. Brooms shall then be used in spreading this first coating of pea stone. The surface shall then be thorougly rolled. and after rolling, the surplus pea stone and dust shall be completely removed by sweeping.

"A second application of bitumen shall then be made in the same manner as in the first application, so as to completely coat the surface, and shall be at the rate of one-half (½) gallon per square yard. After the second application of bitumen has been made, it shall be uniformly covered with a sufficient coating of pea stone, as directed by the engineer, and then thoroughly rolled.

"The bitumen when applied to the upper course of stone shall have a temperature approximating 300° F. for oil asphalt or 200° F. for refined tar.

"Any depressions or irregularities appearing after the final rolling shall be neatly patched in such a manner as shall be directed by the engineer, so that the final surface shall be perfectly uniform and true to the specified cross-section and grade.

"If at any time before the acceptance of the work any soft or imperfect places or spots shall develop in the surface, all such places shall be removed and replaced with new material and then rolled until thoroughly compacted, and until the joints or edges at which the new work connects with the old become invisible. All such removal and replacing of unsatisfactory surfacing shall be done at the expense of the contractor.

"No bituminous work shall be done during rainy weather, nor when weather conditions as to temperature or otherwise are, in the opinion of the engineer, unsatisfactory for obtaining good results.

"The stone shall be perfectly dry before applying the asphalt.

"The contractor shall not allow the asphalt to be overheated or burnt.

"This work shall be paid for as follows:

"The broken stone shall be paid for at the contract unit price per ton rolled complete in place.

"The bituminous material shall be paid for at the contract unit price per gallon heated and applied complete in place.

"The above prices shall include all materials, equipment, tools, labor and work incidental thereto."

In the earlier construction of this type of pavement, asphalt or tar of too soft a nature was used, with the result that roads of that type show a wavy surface after two or three years' use. This condition can only be corrected by rather extensive scarifying, reshaping, and the addition of more material of proper quality and consistency.

Practice has shown that the asphalt or tar to be used in this climate should conform with the following specifications, which are sufficiently elastic to let in all good material of the kind specified and yet are sufficiently stringent so that poor material cannot be used. The specifications mentioned are as follows:

"Oil asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.).

"It shall meet the following requirements:

1. Specific gravity, 25°/25° C. (77°/77° F.)...Not less than 1.000
2. Flash point................Not less than 175° C. (347° F.)
3. Melting point............35° C. (95° F.) to 55° C. (131° F.)
4. Penetration at 25° C. (77° F.), 100 g., 5 sec........90 to 120
5. Loss at 163° C. (325° F.), 5 hours......Not more than 1.0%
   (a) Penetration of residue at 25° C. (77° F.), 100 g., 5 sec., Not less than 60
6. Total bitumen (soluble in carbon disulphide), Not less than 99.5%
   Organic matter, insoluble..............Not more than 0.2%

"Fluxed native asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.).

"It shall meet the following requirements:

1. Specific gravity, 25°/25° C. (77°/77° F.).......1.030 to 1.050
2. Flash point.................Not less than 175° C. (347° F.)
3. Melting point...........40° C. (104° F.) to 50° C. (122° F.)
4. Penetration at 25° C. (77° F.), 100 g., 5 sec........90 to 120
5. Loss at 163° C. (325° F.), 5 hours..... Not more than 3.0%
   (a) Penetration of residue at 25° C. (77° F.), 100 g., 5 sec., Not less than 45
6. Total bitumen (soluble in carbon disulphide), Not less than 95.0%
   Organic matter, insoluble...................1.5% to 2.5%

"Refined tar shall be homogeneous and free from water. It shall meet the following requirements:

1. Specific gravity, 25°/25° C. (77°/77° F.).......1.200 to 1.280
2. Float test at 50° C. (122° F.)...........100 sec. to 150 sec.
3. Total distillate by weight:
   To 170° C. (338° F.)..........Not more than 1.0 per cent.
   To 270° C. (518° F.).........Not more than 10.0 per cent.
   To 300° C. (572° F.).........Not more than 20.0 per cent.
   (a) Melting point of residue, Not more than 65° C. (149° F.)

Total bitumen (soluble in carbon disulphide).....75% to 88%"

During the last few years there has been a great increase in the use of cement concrete as a surface pavement. The first cement concrete section built by the Commonwealth was in the year 1913, in North Andover, and the use of this type of surface

has been gradually increasing from year to year to such an extent that during the year 1921 about one half of the state highway construction was of this type.

The specifications under which the 1921 work was built are as follows:

"The surfacing shall consist of concrete composed by volume of one (1) part of Portland cement, two (2) parts of fine aggregate, and four (4) parts coarse aggregate, constructed on the prepared sub-grade, in one course, and in accordance with these specifications.

"The surfacing shall be twenty (20) feet in width, except on banked curves, where the width shall be twenty-four (24) feet, seven and one-half (7½) inches in depth at the center, and six (6) inches in depth at the side.

"The top surface shall conform to the arc of a circle, with a crown of two and one-half (2½) inches at the center.

"The cement used shall meet the requirements of the standard specifications and tests for Portland cement, adopted by the American Society for Testing Materials, September 1, 1916, with all subsequent amendments and additions thereto adopted by said Society.

"Every facility shall be provided the engineer for careful sampling and inspection of the cement, either at the mill or at the site of the work as may be specified by the engineer. At least ten (10) days from the time of sampling shall be allowed for the completion of the seven-day test; and at least thirty-one (31) days shall be allowed for the completion of the twenty-eight (28) day test. The twenty-eight day test shall be waived only when specifically ordered.

"The water used shall be free from oil, acid, alkalies or organic matter, and neither brackish nor salt.

"The fine aggregate shall consist of clean, hard, durable, uncoated particles of sand, preferably of a siliceous nature, free from clays, soft or flaky particles, loam and all organic matter. Where approved by the engineer, a combination of washed or dustless screenings and sand, containing not more than fifty (50) per cent. by volume of screenings, may be used for the fine aggregate.

"The washed or dustless screenings used as fine aggregate shall consist of material obtained by crushing hard, durable rock or gravel and shall be free from clay and other impurities.

"The fine aggregate shall be well graded from coarse to fine, and when tested by means of laboratory screens and sieves shall meet the following requirements:

Passing ¼-in. screen	100%
Passing 20-mesh sieve	30% to 75%
Passing 50-mesh sieve	Not more than 20%
Passing 100-mesh sieve	Not more than 5%

"The fine aggregate shall be of such quality that mortar composed of one (1) part Portland cement and three (3) parts of fine aggregate by weight when made into briquettes will show a tensile strength at seven and twenty-eight days, at least 100 per cent. of that developed, in the same time, by mortar of the same proportions and consistency, made of the same cement and standard Ottawa sand.

"The coarse aggregate shall consist of clean, durable, broken stone, or gravel stone, free from soft, thin, elongated or laminated pieces, disintegrated stone, vegetable or other deleterious matter. The stone shall have a French coefficient of wear not less than eight (8).

"When tested by means of laboratory screens the coarse aggregate shall meet the following requirements:

Passing 2½-in. screen	100%
Passing 2-in. screen	Not less than 95%
Passing 1-in. screen	30% to 75%
Passing ¼-in. screen	Not more than 5%

"The transverse joint filler shall consist of prepared bituminous paving strips of a quality approved by the engineer, one (1) inch wider than the thickness of the surfacing of a length equal to the width of the surfacing, and one-half (½) inch in thickness.

"The forms shall be of wood or metal, of a width equal to the depth of the concrete, true to line, free from warp and of sufficient strength, when staked, to resist the pressure of the concrete without springing, and so designed that the various sections may be fastened together in such a manner as to prevent vertical or horizontal movement of the ends.

"If of wood, they shall be two (2) inch surfaced plank, not less than twelve (12) feet in length unless otherwise ordered by the engineer. The top of the wooden forms shall be bound with angle irons according to the directions of the engineer.

"If of metal, they shall be of approved section and shall have a flat surface on top of not less than one and three-quarters (1¾) inches.

"The forms shall be joined neatly and tightly, shall be set true to line and grade, well staked and braced, and shall have uniform bearing on the sub-grade throughout their entire length.

In general the setting of forms shall proceed at least two hundred (200) feet in advance of the mixing and placing of concrete. The forms shall be thoroughly cleaned before any concrete is placed against them.

"The forms shall be made tight to prevent the leaking of mortar from the concrete.

"The contractor shall provide sufficient forms so that it will not be necessary to remove them within twelve (12) hours after the concrete is placed.

"The accurate measurement of each of the materials composing and the production of a uniform mixture of the concrete are essential. The contractor shall furnish and use approved timing devices, a water measuring and discharging device, also boxes or pans of such dimensions as will give, when filled and struck, the exact volumes of aggregate required by the engineer.

"The materials shall be mixed wet enough to produce a concrete which will flatten out and quake when deposited in place, but not enough to cause it to flow or the mortar and coarse aggregate to separate.

"The water shall be accurately measured and gaged, and shall be automatically discharged into the drum with the aggregates. The quantity of water shall be determined by the engineer and not varied without his consent.

"Concrete shall not be mixed or placed when the temperature is at or lower than thirty-five (35) degrees F., and no materials containing frost shall be used. Cement or aggregate containing lumps or crusts of hardened material shall not be used.

"The concrete shall be mixed in such quantity as is required for immediate use, and any which has developed initial set or has been mixed longer than forty-five (45) minutes shall not be used. Remixing with additional water, mortar or concrete that has partially hardened will not be permitted.

"In no case shall concrete be deposited upon a frozen sub-grade.

"Concrete shall be mixed thoroughly in a batch mixer of a type approved by the engineer, for a period of not less than one and one-half (1½) minutes after all the materials are in the drum, and during this period shall make not less than fourteen (14) nor more than twenty (20) revolutions per minute.

"The entire contents shall be removed from the drum before materials are placed therein for the succeeding batch.

"If the mixer is operated on the sub-grade, planks shall be provided for the mixer to run on, so that the sub-grade shall be kept in good condition.

"Concrete shall be placed only on a moist sub-grade. If the sub-grade is dry it shall be sprinkled with as much water as will be readily absorbed.

"The concrete shall be deposited on the sub-grade, between the side forms, rapidly in successive batches, by means of a discharging device which does not cause separation of the mortar and the coarse aggregate, and shall be distributed to the required depth and for the entire width of the surfacing by shoveling or other approved methods. Rakes shall not be used for handling concrete.

"This operation shall be continuous, completing sections between expansion or contraction joints without the use of intermediate forms or bulkheads.

"The cement concrete surfacing shall be reinforced with steel deformed rods, and dowels shall be used as shown on the plans and in accordance with these specifications.

"All reinforcing shall be deformed steel rods with a cross-section area of twenty-five hundredths (0.25) square inches, and not less than eight (8) feet long.

"Dowels shall be deformed steel rods for the longitudinal joints, and plain steel rods for the transverse joints, and shall be two (2) feet long and of the same area as the reinforcing rods.

"The reinforcing rods and dowels shall be placed as shown on the plans and in such manner as to insure their remaining in the desired position during the placing and hardening of the concrete. The dowels for the transverse joints shall be painted one-half (½) their length with bituminous material of a quality satisfactory to the engineer.

"This work shall be paid for at the contract unit price per pound for all reinforcing steel rods and dowels.

"The above price shall include all materials, all equipment, labor and work incidental thereto.

"Expansion or contraction joints shall be placed sixty feet apart and shall be made vertical, entirely through the concrete and perpendicular to the center line of the surfacing.

"A longitudinal joint shall also be placed in the center line of the concrete surfacing. If only one half of the width of the surfacing is constructed at one time the face of the concrete shall be painted with bituminous material before the other half of the concrete is placed.

"The longitudinal joint shall be poured with bituminous material according to the direction of the engineer.

"The bituminous material for painting and filling the longitudinal joint shall meet the following requirements:

1. Specific gavity, 25°/25° C. (77°/77° F.) . . . Not less than 0.980
2. Flash point . . . . Not less than 200° C. (392° F.)
3. Melting point . . . . Not less than 80° C. (172° F.)

4. Penetration at 25° C. (77° F.), 100 g., 5 sec. . . . . 30 to 50
5. Loss at 163° C. (325° F.), 5 hours. . . . . . Not more than 1.0%
Penetration of residue at 25° C. (77° F.), 100 g., 5 sec.
Not less than 20
6. Total bitumen (soluble in carbon disulphide),
Not less than 99.5%
(*a.*) Organic matter insoluble. . . . . Not more than 0.2%

"The surface of the concrete shall be struck off by means of a steel template of approved section weighing not less than two hundred (200) pounds for a length of eighteen (18) feet. The template shall be rolled to the desired cross-section and have sufficient strength to retain its shape under all working conditions. This template shall be moved with a longitudinal and crosswise motion, moving always in the direction in which the work is progressing. Care shall be taken in moving the template forward that it is not lifted from the side forms, but shall be held securely against the top of the forms and moved forward uniformly, thus preventing undulations in the surface.

"Immediately after the concrete has been struck off it shall be rolled with an approved metal hand roller having a smooth, even surface, approximately six (6) feet in length, not less than eight (8) nor more than twelve (12) inches in diameter, and weighing not more than one hundred (100) pounds. This roller shall have a handle at least two (2) feet longer than the width of the surfacing, and all the rolling shall be done from one side of the surfacing. The roller shall pass from one edge of the surfacing to the other in one operation, and the rolling shall continue until free water ceases to come to the surface.

"After the rolling has been completed, the concrete shall be finished by using a belt made of canvas or rubber belting not more than twelve (12) inches in width nor less than two (2) feet longer than the width of the surfacing. This belt shall be worked with a longitudinal and cross-wise motion as described for the steel template. Care shall be observed in the use of the belt not to permit the edges to dig into the surface of the concrete or to work the crown out of the surfacing.

"The concrete adjacent to the transverse joint shall be finished with a split wood float which will ensure finishing both sides to the same grade, after which the edges of the concrete at all joints shall be rounded with an approved edging tool to a radius of three-sixteenths (3/16) of an inch and the sides of the slabs to a radius of approximately three-quarters (¾) of an inch. The finishing of the joints shall be done from a bridge which shall not rest on the concrete at any point.

"Concrete surface finishing machines of a type approved by the engineer may be used as an alternate method of finishing to that described above.

"Finally, the surfacing shall be lightly broomed with stable brooms.

"As soon as finished, the concrete shall be protected by a canvas covering, suspended not less than twelve (12) inches above the surface, and, if directed, the surface of the pavement shall be sprinkled with water. When the concrete has hardened sufficiently, the canvas covering shall be removed and the entire surface of the pavement wetted thoroughly and covered with earth or other approved material to a depth of not less than two (2) inches. This material shall be kept moist by sprinkling with water, if directed, and shall remain on the concrete for a period of not less than ten (10) days under the most favorable conditions, or for a longer period if directed by the engineer, during which time traffic shall be excluded from the concrete by the erection and maintenance of suitable barricades, and satisfactory precautions shall be taken to exclude foot traffic for a period of not less than three (3) days. When required or approved, other methods of curing and protecting the concrete may be used.

"After the foregoing period has elapsed, the covering on the concrete shall be removed, the surface of the pavement swept clean and the concrete allowed to cure for a period of three (3) days, after which the roadway may be opened to traffic.

"This work shall be paid for at the contract unit price per cubic yard for 'cement concrete surfacing' complete in place, which price shall include all concrete and contraction or expansion and longitudinal joint materials, all forms, equipment, tools, labor, including rolling, belting, protection of concrete, wetting amd work incidental thereto."

It must not be inferred that bituminous macadam and cement concrete are the only types built by the Commonwealth. Practically every known type of surface appears somewhere in the state highway system, but the prevailing surfaces are of the above-mentioned types.

Proper foundation and drainage have always been looked upon by highway engineers as the most essential requirements for a suitable highway, but they have never been more essential than at present, when loads as heavy as locomotives of a half century ago are permitted to use the highways. The question is sometimes asked, "How thick must the foundation be under a cement concrete road?" and this question is sometimes asked by

engineers who are very competent in their special line of endeavor. No definite answer can be given to such a question, particularly in this state, where the geological formation is so widely variable. In no section of the state is there a road where the subsoil conditions are uniform for a distance of one mile. There are many miles where no foundation whatever is necessary under a suburban highway pavement, while on the other hand there are many miles where foundation 12 ins. to 18 ins. in depth is absolutely necessary.

There are also many miles where no serious attention has to be given to surface drainage or sub-drainage, whereas on the other hand there are many miles where both deep side ditches and under-drains are necessary, and where if these are omitted the pavements will become partially destroyed, necessitating considerable expense for maintenance, particularly after the frost has left the ground in the spring.

Material of two types is generally used by the state for foundation, the first being a coarse, sandy gravel, the second, broken cobbles of variable dimensions up to approximately 10 ins.

In connection with this necessity for adequate foundation it may be well to call further attention to the weights of loads now passing over highways. In 1917 the loading of trucks was increased to such an extent that it appeared that there must be some check to the weights that could be permitted on the highways. The legislature of that year enacted a law limiting the net weight of all vehicles with loads to 14 tons, and with the further restriction that the load on any tire should not exceed 800 lbs. to the inch width.

During the past two years, and particularly in 1921, the Department of Public Works has employed an investigator to ascertain what loads were being carried over the highways and to prosecute the law-breakers as he found them. The extent to which this law has been ignored is remarkable. He found that trucks having a rated capacity of 5 tons and weighing approximately 5 tons were carrying loads weighing from 10 to 15 tons, so that the total load of truck and vehicle was approximately from 15 to 20 tons, and with the worn-out tires on many of the trucks, the load per inch width of tire was approximately

from 1 000 to 1 500 lbs. Statistics under preparation by the department will show that this overloading is not confined to isolated cases, but is very frequent, and must be considered not only in connection with road surfaces and foundations but in connection with the designing of bridges.

The cost of road construction to-day averages about six times greater than that of thirty years ago. Several conditions have led to this increase. In the old days of horse-drawn vehicles, a road surface 15 ft. wide was considered adequate on all surburban roads, and in many cases a surface 12 ft. wide was sufficient. The same roads to-day need surfaces at least 18 ft. wide, and in many instances 24 ft. The minimum width constructed anywhere to-day is 15 ft. On main through lines of travel where the number of vehicles per day is sometimes as high as 3 000, the width should be at least 20 ft with a sufficient width of suitable shoulder to make an aggregate available width in emergencies of 26 ft.

On the road between Worcester and Springfield a large amount of reconstruction has been carried on during the present year, and the width, in this case, of hardened surface has been made 20 ft., with the foundation carried out 3 ft. on each side to permit future further widening without great expense.

Another reason for the increased cost is the necessity for improved permanent surfaces, and still another is the necessity for more adequate foundation. Where in 1895 a water-bound macadam might be built for approximately $6 000 per mile, a cement concrete or other equally strong surface and suitable foundation cost in 1921 about $40 000 per mile. In 1921 a fair average cost of a bituminous macadam surface 18 ft. wide, consisting of 4½-in. base course and a 2½-in. penetrated upper course, exclusive of all expense except the construction of pavement above the foundation, was about $3.00 per sq. yd. The cost of reinforced cement concrete surface as compared with the above is about $3.05 per sq. yd. It is, however, gratifying to those who are interested in getting as much highway as possible constructed each year to observe that the costs of construction gradually decreased during the year 1921, and the outlook is that with this decrease in cost and with the increased use of

machinery, the expense of road construction in 1922 will probably be less than it has been for several years.

In connection with the state construction in Massachusetts, a few words of explanation of the federal aid for road construction may be of interest.

In the year 1916 Congress passed an Act making an appropriation of $75 000 000, a small percentage of which sum was set aside for road construction in the national forests, and another small sum for maintenance of the Bureau of Public Roads in Washington, and the remainder being divided in the states of the Union, one third in the ratio which the area of each state bears to the total area of all the states; one third in the ratio which the population of each state bears to the total population of all the states; and one third in the ratio which the mileage of rural delivery routes and star routes in each state bears to the total mileage of rural delivery routes and star routes in all the states.

Massachusetts under this apportionment receives about 1.6 per cent. of the funds distributed, which, under the Act of 1916, amounted to $1 105 765.23. This appropriation covered three years.

In 1919 a second appropriation was made of $200 000 000, the share of Massachusetts being $2 946 799.87. A third appropriation has just been made, amounting to $75 000 000, the Masssachusetts share being $1 096 176.04.

The proportion of the cost of a road that the Federal Government will pay is 50 per cent. up to a maximum of $20 000 per mile, with an added 50 per cent. of the cost of any bridge over 20 ft. span included in that project. For example, if a state project is one mile long and contains also a bridge over 20 ft. span, the cost of building the road being $42 000 and the cost of building the bridge being $20 000, the amount the Federal Government would pay, according to this expense, would be $20 000 toward the road and $10 000 toward the bridge.

A condition under which this money is distributed is that the state guarantee to maintain the road after construction. This necessitates laying out of all such roads as state highway before or immediately after their completion; otherwise the state could not make any guaranty.

Discussion.

Mr. John R. Rablin.* — I did not prepare any paper for this discussion, although I was requested to do so, but knowing that Mr. Dean's paper would thoroughly cover the subject I thought it would be tedious for you to hear another paper, although it certainly was not to hear his.

I will say a few words about the work with which I have been connected during the last twenty years, and discuss a few points which occur to me after reading over Mr. Dean's paper.

The Metropolitan Park system, as planned, provided for the acquirement of several woods and shore reservations, connected by parkways. The construction of these parkways was begun in 1895, but no large amount of work was done until about 1898 or 1899. Contrary to the state highway practice at that time, the parkway roads were built of ample width, so that since then we have seldom had occasion to widen the roads. They were laid out and constructed from 26 to 36 ft. in width, as parkways, or "boulevards," as they are commonly known. Some were even as wide as 40 ft. There have been some cases where they were not originally constructed to the full width planned, as the traffic did not require it at that time, but they were laid out with the intention of widening them when traffic demanded it. They were constructed generally with either gravel or water-bound macadam surface. Many were built of gravel, and it is remarkable how some of those gravel roads have stood up even to the present time. Roads constructed with a gravel surface, under our specifications in 1899, are in use to-day by the present automobile traffic, and some of them are in very good condition, merely being surface-treated with asphaltic oil. Many of them, on the other hand, haven't stood up at all. It depends on the quality of gravel used. Of course the fact must be borne in mind that all heavy traffic is excluded from the park roads and only light traffic, such as pleasure vehicles, allowed, and when they were built the reason for making them of gravel was that the light carriages which used them — many of them

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rubber-tired — didn't require macadam. It is quite remarkable that so many of those roads have lasted to this time, because if now we should build a gravel road with asphaltic oil surfacing, it probably would not stand a week. I don't know what the explanation is, unless it is that the old roads had become thoroughly compacted by use before treatment.

Regarding the subject of wavy surfaces, it appeared that some of these gravel roads after several applications of the oil became saturated to such a depth that we had a surface of fine aggregate filled with a fairly soft asphaltic oil, which was unstable under automobile traffic. We also found that our water-bound macadam roads — which were generally constructed with a 4-in. bottom course of No. 1 stone and 2 ins. of No. 2 stone on top, bound with stone dust — when later treated with asphaltic oil became a soft plastic mass and waved very badly. Our later type of construction, when it became necessary to build the bituminous macadam roads, which we now build exclusively, calls for a 6-in. depth of No. 1 stone with the voids near the surface filled with pea stone and No. 2 stone, and thoroughly rolled. Then the bituminous binder is applied. That is somewhat different from the Public Works Department's specifications, described in Mr. Dean's paper, but their depth of stone is greater than ours. We get a very good, compact surface with one 6-in. course, well rolled. By having the No. 1 stone — the larger stone — at the surface bound together with asphalt or tar binder, the tendency to bunch up and roll up and wave is eliminated.

With reference to gravel and water-bound macadam surfaces, some of the original costs are interesting. I looked up some of the old costs of our department recently, and found bids received for gravel surface which called for 5- to 6-in. depth of approved gravel, ranging from 15c. to 50c. per square yard. They were built for from 15 to 25c.; and bids for water-bound macadam from 30 to 57c., generally built for less than 50c. per square yard.

On our re-surfacing of old macadam and gravel roads, which has become necessary in many instances since the automobile traffic developed, we have used from 3 to 5 ins. additional stone, and have constructed by the same specifications as in new construction.

The bituminous macadam costs in our work have ranged in 1915 and 1916 from 60c. to 90c. per sq. yd., including binder; in 1919, from $1 to $1.50 per sq. yd., including binder; and in 1921, from $1.50 to $3.50. Those are bids. The work has actually cost in the last two years from $1 to $1.50. That cost is for the surface only, and does not include grading, drainage or anything else.

Statements of the cost per mile of constructing various types of road are of little value for comparison, because, as Mr. Dean explained, they started in the State Highway Commission to build their roads 12 to 15 ft. wide and are now building them 20 to 24 ft. wide. We build ours 26 to 36 ft. wide. The cost per mile doesn't mean anything unless the width of road is given. We have been criticized for having a higher cost per mile of road than that of the state highways, the width not being taken into consideration.

Our re-surfacing costs for bituminous macadam in 1915 were from 60c. to $1, and in 1919 from $1.10 to $1.50, in 1920 from $1 to $1.60 per sq. yd. Now we estimate about $1.50 on the average for re-surfacing with bituminous macadam on existing roadways. It costs more to re-surface a gravel road than a macadam road because we get the benefit of some of the stone in the old macadam roads.

In the acquirement of the park system, certain existing roads were taken over. These must be built and maintained for heavy traffic, mixed traffic, all kinds of traffic, and we usually lay on those roads what we consider a better type of pavement than we would lay on the strictly park road. This class of road is similar to the state highways. On these, we have used bituminous concrete pavements and Portland cement concrete pavements. With reference to bituminous concrete pavements, Mr. Dean didn't mention that type in his paper. I don't know whether he purposely omitted it or not. I refer to a class of so-called "patented pavements" such as the Bitulithic, Warrenite, Topeka, Bitoslag, Unionite, National, etc. All are more or less of the sheet asphalt type and are laid either on a concrete base or upon a macadam base. We have recently tried the experiment of laying a few short stretches of these surfaces on old macadam

bases, and at the present time they are standing up very well. Using a 2-in. top we have laid sections of Warrenite, Topeka and Bitoslag. The Bitoslag is built by substantially the same specification as the others, merely substituting slag for the crushed stone.

In the Portland cement concrete pavement the specification read by Mr. Dean, providing for the reinforcement, referred to the plans showing just where and how it should be placed. I think there is still, and has been for some time, some question as to just where and just how much reinforcement to put in the concrete road surfacing, — whether it shall all be placed at the top, all at the bottom, or in both places. The stresses, of course, in a concrete road are somewhat different from those in a slab floor or roof, and I am not prepared to say just where or how much reinforcement ought to be used. In fact, perhaps some of you may remember that a year or two ago a gentleman talked to us here about concrete pavements, and made the statement that you should use as much reinforcement as you had money to spend for it. That was, of course, somewhat indefinite — he intimated none was needed. I think, however, since then most engineers and experts on road construction have come to the point where they approve of reinforcement in the concrete roads. Although it does not entirely prevent cracking, it probably lessens it considerably and holds the pavement on a true plane. After it has cracked, one section doesn't rise above the other or settle below the next.

I think it is only quite recently that the longitudinal joint has been used to any extent, in the construction of concrete road surfaces, and it is my opinion that it is quite necessary, as the longitudinal crack which almost invariably appears is more unsightly than the transverse crack. Generally, especially if the pavement is reinforced, there is no injury to the pavement because it cracks. It is merely unsightly, and if filled with pitch or asphalt causes little damage to the pavement.

There are still other types of cement concrete pavement. There is a Portland cement concrete pavement which I think is controlled by patents, — at least a certain part of the work is, I understand, — the Hassam pavement, in which the stone is

laid as in the ordinary macadam pavement and grouted with cement grout and rolled as it is grouted. The claim is that the wear comes upon the stone directly, and not upon the film of cement mortar which covers the stone in a mixed concrete.

Recently, there has been brought to my attention another type which is called "Soilamies." If this pavement proves all that is claimed for it, it is expected that it will reduce the cost of cement concrete pavements from 30 to 40 per cent. Briefly, the specification is — and its name comes from this fact — that any soil that is found in the subgrade may be used for aggregate. They expect to excavate the road surface to subgrade and use the excavated material to mix with their cement and a secret ingredient which allows any soil, whatever it may be, to be used as the aggregate. There have been some experimental sections of this laid — mostly in Pennsylvania, I believe. As to its merits, of course we only know what we have been told.

In the matter of foundations, one point occurred to me which I thought might be of interest to you, — that we have found, where we have a clay subgrade, that if we lay crushed stone or a coarse gravel over it, before laying our macadam, in a few years, if we have occasion to excavate, most of the stone seems to have disappeared and the clay to have come to the surface or mixed with the stone. This action is probably due to frost and moisture. We have also found that by covering the clay with a layer of fine sand before putting on the coarse gravel or stone, it will prevent that to a large extent.

The question is asked as to how the Hassam pavement compares in cost, life and wearing qualities with the type of pavement that Mr. Dean specifies.

I think I can hardly answer that, not having had the experience with the use of this pavement a sufficient length of time. The cost at the time we built a section about two years ago was less than the cost of the ordinary concrete specification under that contract.

There is one thing that I do not approve about the "Hassam" specifications, and that is that they omit joints, either longitudinal or transverse. The pavement cracks, as all concrete pavement does, and of course the cracks are irregular in all

directions. It seems to me that joints could be provided in that type as well as in the other. It might be more difficult, but I think it could be done, and should be done. You can provide for expansion and contraction joints in the mixed concrete, and I think you could in this.

As to its wearing qualities, I couldn't give an opinion on that at the present time.

MR. HENRY V. MACKSEY.* — I have been very much interested in Mr. Dean's paper. It seems to me that we should pay more attention to the elimination of dangerous places on highways. I can readily understand the attitude taken by the Public Works Department of the Commonwealth in building roads, because it never has money enough to do all that it would like to do. It is forced, as we are in little towns, to make as many miles as possible with the amount of money available; but it does seem that changes might be made in the policy of the Commonwealth. It now contributes out of its funds to the construction of gravel roads. There never was a rule made that will not admit of an exception, and I am willing to admit that in the very small, poor towns, where a decent highway is needed in order to provide for through traffic, it is well to give money to help build gravel roads; but in a town that has a considerable traffic itself and has means and money, the state should not contribute toward building gravel roads. The towns should take care of their own gravel roads and the state should help them to build permanent roads.

In laying out state highways, where old roads are to be improved, almost always the old road is taken as it is and slightly improved. At a railroad grade crossing we do not separate the grades. It is just as important to separate grades where a highway meets a railway as to separate grades where two railways meet. A collision between a train and a jitney carrying forty people may mean little to the railway, but it may mean forty lives.

In regard to the different types of pavements, we really haven't had modern concrete pavements in this section long enough to know just how they compare with others in durability,

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but I think the whole story will be told by the foundation which supports the pavement. Pavement, after all, is but a covering. If you reinforce a concrete pavement and the frost heaves up the edges, you may have sufficient reinforcement to hold the pavement up as a beam without cracking. If you have a bituminous pavement it will crack under such conditions but will cement itself together again, which concrete pavement will not do. There is not a great difference in cost between the two, but it is an open question whether we should always prefer cement concrete. As Mr. Larned said, there are many times conditions other than durability to be considered. For instance, a question recently came before the board I work with. They were asked by a Finance Committee to put cement concrete pavement on one of the main roads of the town, which is not built up at all on one side and only slightly on the other. There is a good prospect of building operations very shortly, and in the near future we would have to lay a sewer, and would cut the pavement for that the entire length of the street, and also for water services, gas services, sewer connections and water connections. In making cuts the difference in cost is not great if you have kept clear of that infernal reinforcement. But the cost and inconveniences are considerable, as it takes two weeks to season concrete so that you can allow traffic over it, whereas with bituminous pavement we allow traffic on it within an hour. I have been surprised to find that in the last year or two the policy of the Massachusetts Highway Department has apparently changed. Five or six years ago it was strongly in favor of the hot mix — bituminous pavement — and it laid a great deal of such pavement. It was very good, has lasted well, and most of it has not waved. Of course some was poor, because that class of pavement requires not only good material but expert workmen and inspectors, which were not always provided. It is very difficult for the Massachusetts Highway Department to always take the best contractor from among the bidders. It cannot, like a private party, turn down a man because it thinks he will not do good work. He is the low bidder, shows his bond and agrees to work according to specifications. Reliable inspectors are hard to get. The younger men just out of college

have not had enough experience to tell them when they can put their foot down and hold it down, and when they can't. Many times they will make too much of a trifling matter and let the large one pass. There are many stages of the work which need to be watched in a mixed concrete job, whether it is bituminous or Portland cement. One of the commissioners of the Massachusetts Highway Department has stated that to lay concrete right they needed four inspectors, but they never have that many.

There is considerable virtue in bituminous pavements, and I am surprised that bituminous concrete is not laid now by the State Department.

The bituminous penetration type is the ideal pavement for a little town to build. It can be built with less plant and less skilled labor than any other durable pavement, but it does require surface treatment for maintenance, You must seal it frequently. You will get a better pavement by using nothing but No. 1 stone, or even larger. It is a stone road, and bitumen used only to hold the stone in place. Why not stones as large as can be held together? I believe that a change should be made in the state specifications, eliminating the smaller sizes, even though the cost be greater.

A. P. PORTER.* Before an engineer can design a structure, or any part of a structure, it is necessary for him to know three things: first, what loads it is to carry; second, what stresses these loads will cause, and, third, what materials will resist these stresses.

In the design of pavements the highway engineer has concerned himself principally with the third consideration, what materials to use. The last year has seen the first determined attempts to solve the second question; witness the experimental road in Pittsburg, Calif., and the tests conducted by the Bureau of Public Roads at Washington. At the present time much attention is being paid to the first-mentioned consideration, namely, the loads coming upon the highways.

The speaker can give some first-hand information on the subject of loads, because, for the past two summers, he has been

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employed by the Massachusetts Department of Public Works, under Commissioner John N. Cole, investigating the heavy loads imposed on the highways by motor trucks.

We started to weigh the trucks with two loadometers. The loadometer is a device on the screw-jack principle, with an oil gage attached to give the weight. The two instruments are first placed under the rear axle, screwed up until the wheels are off the ground and the readings taken. Then this process is repeated with the front axle. The sum of the four readings gives the total weight of truck and load.

In using the loadometers, I found it is wise to choose a spot where the roadway is nearly level in both directions, for if one of the jacks stands on the sloping shoulder of the road, the side thrust will cause the screw to bind, and not only work very hard but may affect the readings.

During 1920, 90 trucks were weighed by the loadometers, and in 1921 100 trucks by the loadometer and 400 on platform scales.

The first two jacks which I used were calibrated to 20 000 lbs. each, but the second pair, supposed to be an improved model, have a capacity of only 15 000 lbs. each.

The first truck I met after I began using these improved jacks was too heavy to be weighed with them and I had to resort to a neighboring 20-ton platform scale. The rear axle of this truck weighed 33 200 lbs., the heaviest axle load I ever weighed.

The largest gross weight of a four-wheeled truck and load which we actually weighed was 38 300 lbs., and the largest load on six wheels was 40 000 lbs. The accompanying diagrams (Figs. 1 and 2) show the maximum loads we encountered. Undoubtedly there were some larger than these which did not happen to come our way.

Fig. 3 shows all loads over 24 000 lbs. plotted so as to show the total weight, and also the weight on the rear axle for each truck. This latter data will be of interest to the engineer who designs short-span bridges and floor systems.

The proportion of the weight which comes on the rear axle of a truck varies from 70 to 87 per cent. It is not constant for a certain truck. As more load is added, the percentage on the rear increases.

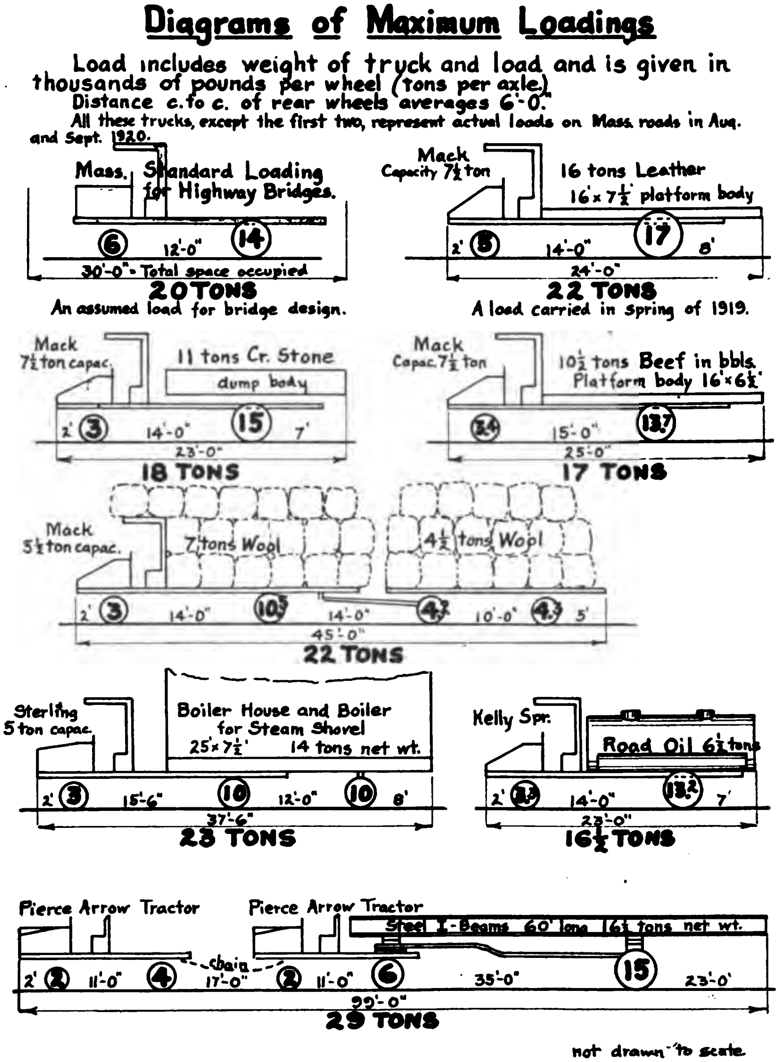


FIG. 1 — MAXIMUM LOADS ON MASSACHUSETTS HIGHWAYS.

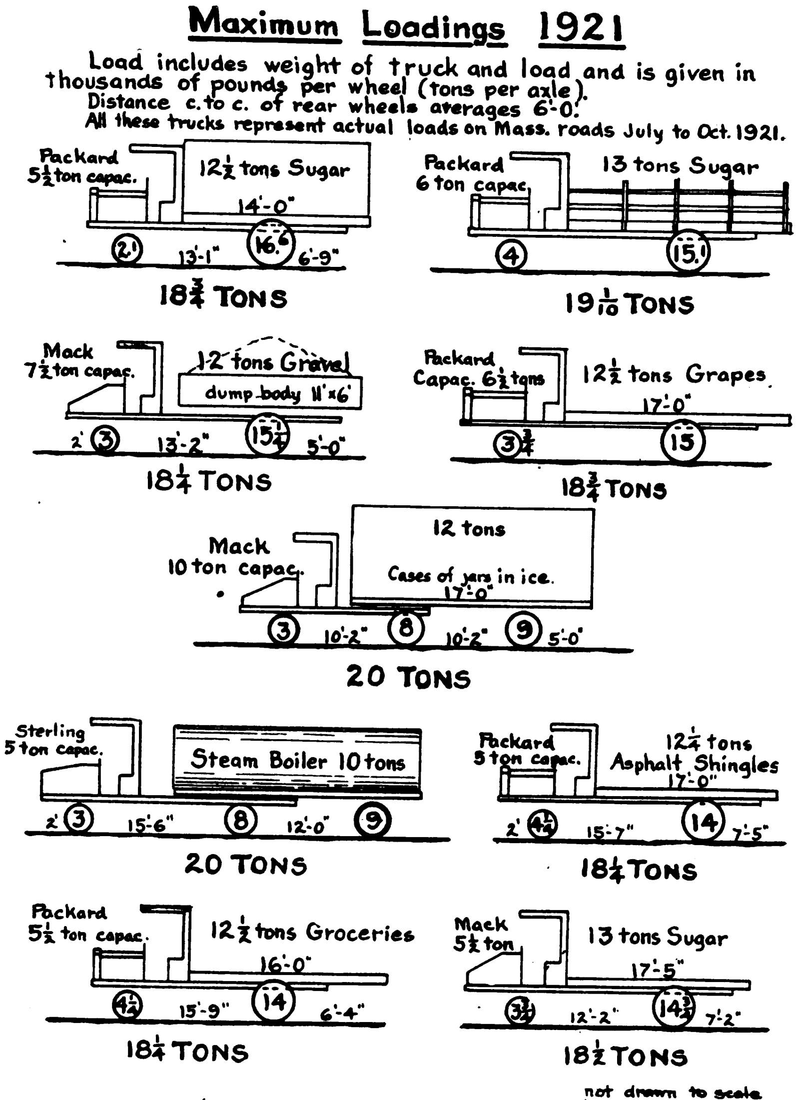
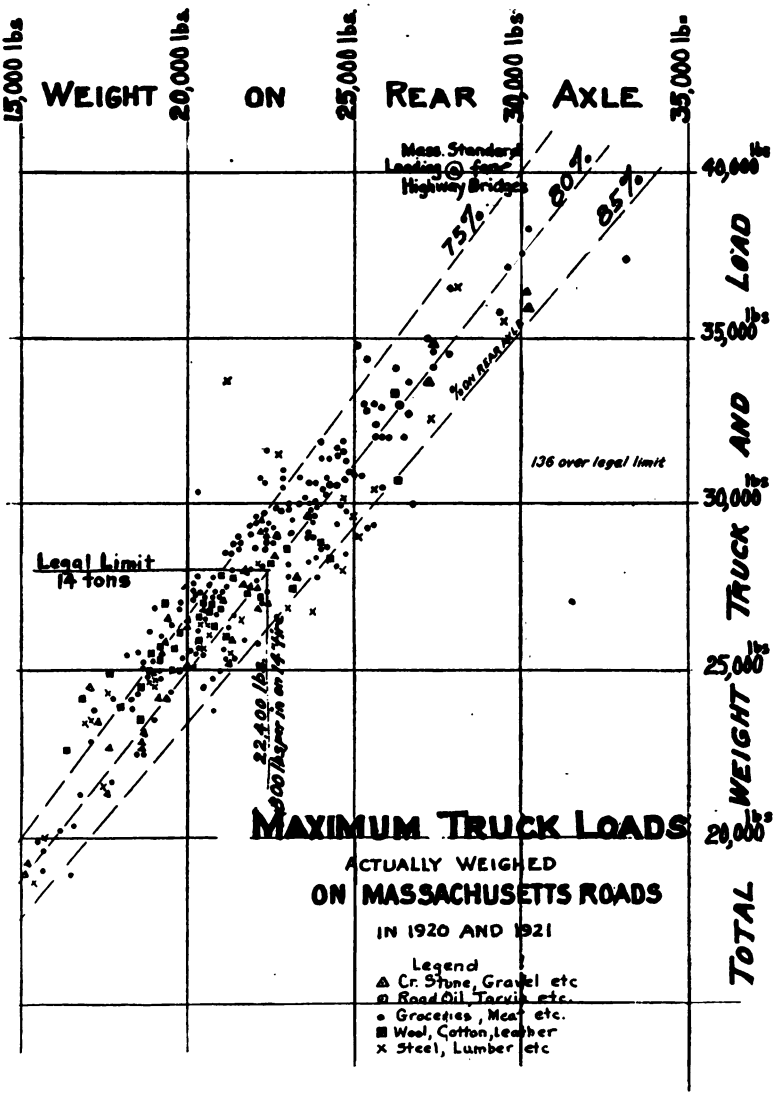


FIG. 2 — MAXIMUM LOADS ON MASSACHUSETTS HIGHWAYS.



15,000 lbs
WEIGHT
20,000 lbs
ON
25,000 lbs
REAR
30,000 lbs
AXLE
35,000 lbs
Mass. Standard Loading @ fans Highway Bridges
75%
80%
85%
% ON REAR AXLE
40,000 lbs
35,000 lbs
30,000 lbs
25,000 lbs
20,000 lbs
TOTAL WEIGHT TRUCK AND LOAD
136 over legal limit
Legal Limit 14 tons
22,400 lbs
MAXIMUM TRUCK LOADS
ACTUALLY WEIGHED
ON MASSACHUSETTS ROADS
IN 1920 AND 1921
Legend
Cr. Stone, Gravel etc
Road Oil, Tarvia etc.
Groceries, Meat etc.
Wool, Cotton, Leather
Steel, Lumber etc

FIG. 3.

It varies also with different makes of truck, different classes of commodities, length of wheel base, length of body, overhang, and how the load is placed. The Autocar has more of its load on the front. Loads of wool or cotton are sometimes piled forward over the cab. The average per cent. on the rear, for all makes, is about 78.

The legal limit in Massachusetts for the weight of truck and load is 14 tons, and outside the Metropolitan Parks and Sewerage districts there is also a limit of 800 lbs. per inch width of tire. Since the largest tire practicable is 14 ins. wide or its equivalent, two 7-in. tires, this practically limits the legal axle load to 22 400 lbs. even with the largest tires.

When the weight of the truck and load was over the legal limit several hundred pounds or more, we summoned the driver to court. So far this year we have had 116 cases in court and secured a verdict of guilty in 109 cases.

Sometimes we made the truckman remove part of his load. On one occasion in Reading, I stopped a truck going from Boston to Lowell which weighed 38 300 lbs., and another owned by the same company going to Lawrence which weighed 34 100 lbs. When told they could not proceed, they telephoned to Boston for another truck, which came out and took 25 barrels of sugar off of one truck and 17 off of the other, which made this third truck overweight.

When we started the investigation there were three facts we wanted to determine:

1. *The Maximum Load.*—Actual weight of heaviest truck load and how its weight is distributed on the wheels. This is to be used as a basis for computing the greatest stresses in the pavement and in bridges.

2. *Overloaded Trucks.*—The ratio of the actual load to the manufacturers' rated carrying capacity is called the "load factor." While we found some trucks carrying as much as two or three times the rated capacity, the average load factor for all the trucks carrying any load is about 1, and taking into account the trucks returning empty the average load factor is about 0.5.

3. *Intensity of Traffic.* — A highway engineer is often called upon to compare the traffic over one road with that over another. For this purpose it is necessary to stop every heavy truck passing a certain point, ask the driver a number of questions regarding the weight of his truck and load, and find the total weight of all the trucks in a given period of time. I adopted "tons-per-hour" as being probably the most convenient unit to express the volume of traffic. For instance, if one road carries ten times as many tons per hour as another, it is reasonable to suppose that the former road will wear out about ten times as fast as the latter and cost ten times as much to keep up, other things being equal.

The diagram entitled "Intensity of Truck Traffic" (Fig. 4) shows first the average weight in tons per hour of the commodities carried: i.e., the pay load; and secondly, the average gross weight of the trucks and loads passing that point, including the weight of the trucks returning empty. The former is an index of the relative economic value of the road to the community. The latter is a measure of the relative wear due to trucks. Pleasure vehicles and light trucks are not included in this diagram.

We divided the commodities carried into five groups:

1. Crushed stone, gravel, etc.
2. Oil, gasoline and tarvia in tank bodies.
3. Groceries, meat and drinks.
4. Wool, cotton and dry goods.
5. Machinery, lumber and furniture.

Our analysis of these figures shows some interesting conclusions; among others, that the loads going out from the city are very much greater than the loads going in toward the center. About 75 per cent of the net load on any one of the through routes is going out from Boston, and only 25 per cent coming in. If these could be more nearly balanced, the efficiency of this kind of transportation would be very much increased.

In regard to the effect of the heavy trucks on the roads, it seems to me it is the arch action between the particles of broken stone in the road surface that crushes them. The vertical pressure would not be sufficient.

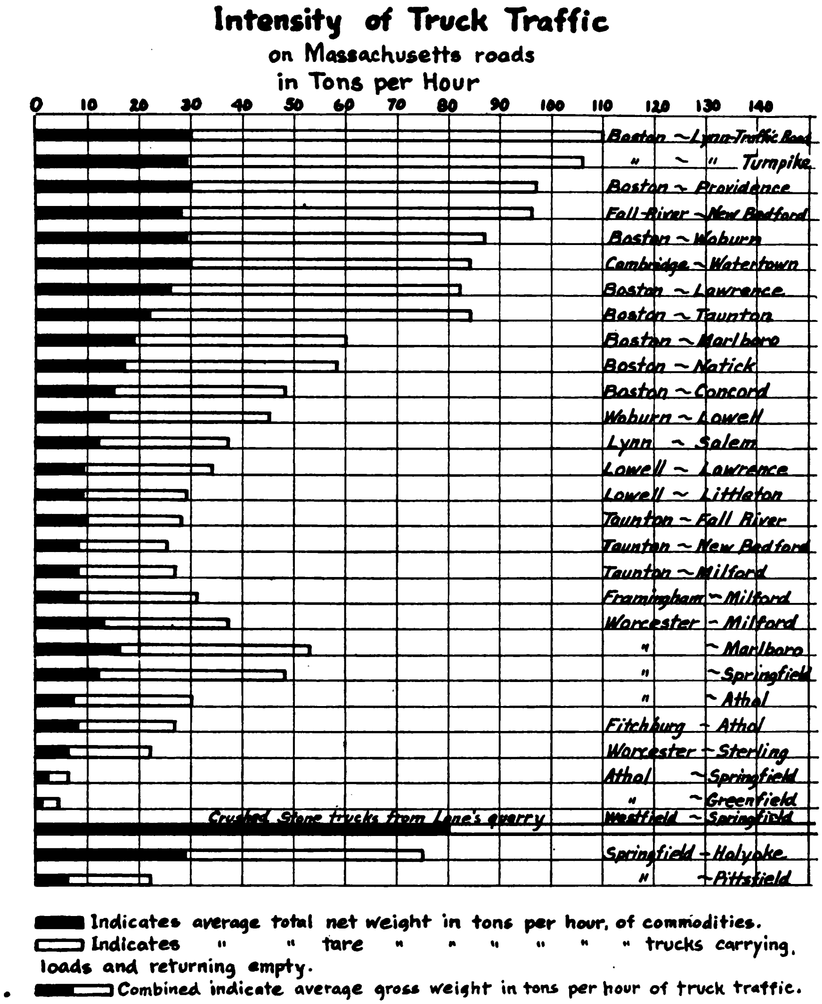

Intensity of Truck Traffic
on Massachusetts roads
in Tons per Hour
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140
Boston ~ Lynn-Traffic Road
" ~ " Turnpike
Boston ~ Providence
Fall-River ~ New Bedford
Boston ~ Woburn
Cambridge ~ Watertown
Boston ~ Lawrence
Boston ~ Taunton
Boston ~ Marlboro
Boston ~ Natick
Boston ~ Concord
Woburn ~ Lowell
Lynn ~ Salem
Lowell ~ Lawrence
Lowell ~ Littleton
Taunton ~ Fall River
Taunton ~ New Bedford
Taunton ~ Milford
Framingham ~ Milford
Worcester ~ Milford
" ~ Marlboro
" ~ Springfield
" ~ Athol
Fitchburg ~ Athol
Worcester ~ Sterling
Athol ~ Springfield
" ~ Greenfield
Crushed Stone trucks from Lane's quarry
Westfield ~ Springfield
Springfield ~ Holyoke
" ~ Pittsfield
Indicates average total net weight in tons per hour, of commodities.
Indicates " " tare " " " " " " trucks carrying, loads and returning empty.
Combined indicate average gross weight in tons per hour of truck traffic.

FIG. 4.

Suppose there is a little settlement in the soil underneath. The pieces of broken stone form a flat arch which will support autos or light trucks, but under the very heavy truck loads, eight tons or more on one wheel, the horizontal thrust becomes enormous and the arch breaks down. It has been found in excavating old roads that stone near the top surface had become pulverized.

Something was said about a comparison between concrete and bituminous macadam. On Beacon Street, at Chestnut Hill Reservoir, there is a stretch of macadam between two stretches of concrete. The concrete is badly cracked, due apparently to the subsoil sliding toward the reservoir, but the macadam is smooth. As some one said, when macadam cracks, it sticks together again. This quality would indicate its use in cases where there is a possibility of unequal settlement.

MR. DEAN. — I am only going to speak about two minutes. Mr. Rablin spoke about the location and amount of reinforcement in a concrete road. Any bridge designer or building designer will find some way of determining when a portion of a structure is in stress and when it is in strain, and how much the stress and strain is. They can then determine how much reinforcement to use and where to put it. Part of the time steel reinforcement in a road surface is in tension, when the frost is coming out of the ground or in the ground, and part of the time it is in compression. Frost doesn't seem to act twice the same way at the same point. We proved this at North Andover on a road which we called a demonstration road, and not an experimental road. We found that at the same point where one year frost would thrust the road up 6 ins. on one side the following year that point would be down. At another time the same point would be only up 3 ins., the other side up and the center down, or the center up and the other side down. Consequently, the slab is sometimes a beam and sometimes a cantilever. The only way we can effectively reinforce an 8-in. slab on a roadway is to make it practically all steel, or to make it strong enough to hold up the road when only supported on one side or the other.

The main object, in my mind, in using steel is to prevent cracks that result from the heaving action of frost, and to prevent the cracks from growing if once formed.

I might state in answer to what Mr. Rablin has said concerning many of the park boulevards of gravel, with just an oil or tar coating on top, that a year ago last spring, on one of the state highways where the road had been built with from 6 to 8 ins. of broken stone on a good foundation, there was one place where thirteen trucks were mired within a mile and had to be pulled out, which to my mind demonstrates conclusively that the truck is the real menace to the road today and in the future. The ordinary pleasure vehicle, while it is injurious to the old type of road, is not nearly as injurious to the new type as is the heavy motor truck.

With reference to some remarks by Mr. Larned concerning bituminous macadam, I must defend myself and my remarks from misinterpretation. Mr. Larned is probably familiar with the state highway through Wayland and Sudbury that has been built of bituminous macadam, — the first section about ten years ago. It has cost in the vicinity of ½ c. per square yard per year for maintenance of that surface, and it has cost practically the same amount for the maintenance of cement concrete surfaces. We have many miles of bituminous macadam down six to eight years, in which the maintenance has not been in excess of 1c. per square yard per year, and with that experience (with the actual costs separated from the costs of the other portions of the road — the shoulders, etc.), we feel perfectly justified in building a first-class bituminous madacam road. My belief is that with these trucks, these conditions, the situation is the same as with the railroads. We have got to have sufficient ballast under the railroad track if we are going to carry big locomotives and sufficient foundation under the road surface if we are going to carry 20-ton trucks. I don't think that the surface, — judging from my observations, — provided you get a good, well-built surface, is nearly as important as what you put under the surface and how much you put under the surface. If a bituminous macadam road will stand up for ten years at ½c. per sq. yd. per year, it seems to me that it has demonstrated that its use is warranted.

I recently had occasion to look up some cost figures, and got the average cost for a 7-in. surface, — 4½ ins. of broken stone base

and $2\frac{1}{2}$ ins. of top. It costs $2.50 per sq. yd. for that 7 ins. And cement concrete with reinforcement costs about $3 per sq. yd. at present contract prices. So the concrete surface costs about 50c. per sq. yd. more than bituminous macadam.

I do not wish to give the impression that I do not approve of cement concrete surface, for I do approve of it and believe we should build more.

Mr. Dorr inquires about the economic phase of the truck problem. I think that is a condition we have got to meet to a certain extent. I don't think that the public is expected to build roads for carrying carload lots over the highways, but for ordinary loads, and I think our present law, that limits the load to 14 tons including the vehicle, is about as high as we should go in permitting trucks and merchandise to go over the highways. We do not and should not, in my opinion, attempt in any way to curb the use of the highways for commercial vehicle purposes, but should curb commercial vehicles from attempting to carry 20 or 30 tons over the highway. We have got to have the railroads for long-distance traffic, and I don't think they should be put out of existence as the state railways have been, in order to permit trucks to carry extremely heavy loads — carload lots — over the highways.

It is considerable of a question whether those heavy loads are economical or not. That is being experimented on, — whether it is more economical to carry heavy loads long distances (50 or 75 miles) or to carry moderate loads. It is still indeterminate. The method of using trams on the highways has been used and tried, but my observation has been that where they have been tried they have not been continued long. They have been tried for short distances, but where they have been tried they have not extended those trams any further. So it would appear that they had not been found an economical construction. It is very difficult to construct a tram in a highway and not have the highway break down where the tram rail joins the highway surface, just as it is very difficult to keep the pavement up alongside a street railway track. It is always breaking down there. Granite block is constantly working up and down.

I have not had occasion to treat the surface of our concrete roads, to which reference has been made, in but one or two instances. In both of these instances they were treated because the concrete itself had become bad. It was not properly constructed when built. California roads that were going to pieces have been mentioned. In California several years ago they issued 50 million dollars' worth of bonds and built roads 4 ins. thick. Experience has demonstrated those were not the proper roads for their conditions. I do not know any surface treatment that can be given to any cement concrete road that will not be expensive to maintain. Whether you use asphalt or tar, it will wear off unevenly and can only be made even by very careful hand work. I don't think it is going to be practical to treat the surface of a concrete road with anything less than 1½ ins. in thickness. I do think perhaps a light oil may be used as a dust layer, but it will have to be very light and will have to be applied quite frequently, and of course is objectionable and makes always a dirty surface.

Mr. Macksey asks if for ordinary traffic a 6-in. Portland cement concrete surface, not reinforced, is as safe a proposition as a 6-in. bitumen macadam surface.

This depends very largely upon the traffic and upon the foundation. If you have good, dry, gravel subsoil, 6-in. macadam or 6-in. cement concrete without reinforcement will probably last a great many years, and then can be strengthened by 1½ or 2 ins. of bituminous mixture; 6-in. bituminous macadam under certain conditions might need a little more foundation than would the 6-in. concrete, in order to make it a little stronger. There is not very much choice between 6-in. cement concrete without reinforcement and 6-in. macadam. We have quite a number of miles of both.

Vol. IX FEBRUARY, 1922 No. 2

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

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CHARACTERISTICS OF SOME CONNECTICUT SLUDGES.

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(Presented before The Sanitary Section, January 4, 1922.)

ONE very important feature in the design and operation of sewage treatment works, and one heretofore too often given the least consideration, is the treatment and disposal of the sludge. No investigation of sewage from large cities can to-day be considered complete that does not include a careful study of the economic treatment and utilization of the sludge. The feasibility of recovering nitrogen and extracting grease from sludges, burning for fuel value or developing gases for generation of power has been at times demonstrated with varying degrees of success, but where such utilization was practiced, local conditions were particularly favorable and a successful method of general applicability still remains to be found. In fact, local conditions and requirements, rather than sludge utilization, govern the selection of sewage and sludge treatment for any particular community.

The importance of returning nitrogen to the soil in order to increase the food supply has been emphasized by scientists all over the world and considerable research work has been done in trying to obtain plant nitrogen from the atmosphere and also from sewage. To support the contention that available nitrogen is being wasted, figures are often given, the significance of which because of their magnitude cannot be quickly grasped, and

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TABLE I.

SLUDGE ANALYSES

Sludge	Specific Gravity	% Moisture	Dry Basis Tests: % Mineral	Dry Basis Tests: % Volatile	Dry Basis Tests: % Nitrogen	Ether Extract: % Plain	Ether Extract: % Acid	Per Million Gallons Sewage: Cu. Ft. Wet Sludge	Lbs. Susp. Sol. Removed from Sewage	Lbs. Dry Solids in Sludge	% Recovery Suspended Sol.	Lbs. Nitrogen in Sludge	Lbs. Plain Ether Ext. in Sludge	Lbs. Acid Ether Ext. in Sludge.
NEW BRITAIN														
Grit Chamber. Grit	1.36	52.3	74.8	25.2	0.70	2.9	6.6	0.18	...	6.0	...	0.42	0.17	0.40
Grit Chamber. Scum	.98	52.1	20.2	79.8	0.68	62.7	66.5	0.28	...	6.7	...	0.46	4.21	4.56
Screenings. $\frac{1}{16}$" x $\frac{1}{2}$" Slots	1.08	81.0	...	...	...	...	...	30	...	380	...	...	...	...
Imhoff Tank	1.05	90.0	48.3	51.7	2.37	14.3	19.5	72†	525†	470†	89.5†	11.1†	67.2†	91.5†
Secondary Tank	1.03	93.8	51.5	48.5	2.88	12.0	22.8	94	380	383	100.7	11.0	46.0	87.3
Total Imh. and Sec. Tank	...	...	...	...	...	...	...	166	905	853	94.3	22.1	113.2	178.8
Activated Sludge*	1.004	99.56	35.4	64.6	4.10	13.0	19.3	2950	859	810	94.5	33.2	105.3	156.2
Miles Acid	1.025	95.0	26.5	73.5	3.10	21.6	30.3	95	767	308	40.1	9.6	65.5	93.4
SOUTH MANCHESTER														
Plain Sedimentation	1.025	95.6	26.6	73.4	4.62	29.2	37.5	162	470	455	96.8	21.0	132.8	170.5
Lime Treatment	1.03	95.5	39.5	60.5	1.48	21.3	...	607	524	1760	...	26.0	374.5	...

*Untreated. †After 3 months' storage.

they weaken rather than strengthen the argument. When we are told, however, that in the maximum consumption of fertilizer in the world of 1 300 000 tons per year only a third is from artificial sources, and when we consider further the recurring food problems of Europe and Asia, and that about 5 000 000 tons of nitrogen per year are wasted from the human body, we are impressed with the fact that there is a great field for the engineer and chemist in developing methods for conserving this waste. Sewage sludges, however, as we know them, are of such composition and characteristics that we have been able to recover and use only an insignificant part of their valuable constituents. In most cases we have been content if we obtained fairly inoffensive sludge disposal.

In our study of Connecticut sludges produced at sewage experiment stations, many points of interest have been noted regarding composition, treatment and possible utilization, and it is the purpose of this paper to discuss briefly some of these.

TABLE 2.

SEWAGE ANALYSES

P. P. M.

Determination	New Britain	South Manchester
Nitrogen as Organic	12.9	17.7
Nitrogen as Free Ammonia	13.2	7.2
Nitrogen as Nitrites	.25	0
Nitrogen as Nitrates	1.93	0.57
Oxygen Consumed	43	141
Total Suspended Solids	129	183
Volatile Suspended Solids	93	154
Chlorine	40	45
Alkalinity	118	70

Analytical data concerning these sludges is found in Table 1, while Table 2 shows the composition of the sewages from which the sludges were produced.

Grit Chamber, New Britain. Comparison of Grit and Scum.

The grit chamber at the New Britain station treated an average of 90 000 gallons per day, with a retention period of half a minute, inlet velocity of .4 ft. per second, outlet velocity .9 ft. per second. A small baffle across the outlet end retained considerable scum on the surface of the chamber. The grit was black in color, very odorous, and at times contained comparatively large amounts of matter other than true grit, such as spaghetti and pieces of vegetables. The scum differed in appearance from time to time, frequently resembling a heavy dark oil and at other times a dark yellowish grease. It usually had a stale greasy odor.

The grit and scum were practically identical in moisture content, which was very low, averaging about 52%, and in nitrogen content, which was also very low, averaging about .7 of 1%. There was, however, a marked difference between them in other constituents. Of the grit, 75% was mineral matter, while the scum contained 80% volatile matter. Ether extract, both plain and acid, were at least ten times higher in the scum than in the grit. Theoretically, the scum should be quite valuable from the standpoint of grease extraction, as it contained 63% plain ether extract. Actually, however, the amount of scum was so small that only 4.2 lbs. of plain ether extract would be produced per million gallons sewage, or about 16 lbs. per day, from the total New Britain sanitary sewage.

Drying on sludge beds and dumping on spoil land would be the simplest method of disposal of both grit and scum. After drying on the beds, the scum, however, could probably be mixed with coal and burned under boilers, as the amount of volatile matter would be very high and the moisture quite low.

Screenings

A seven-day performance test was made on the New Britain sewage, using a standard Dorrco drum screen with slotted perforations $\frac{1}{16}$th inch by ½ inch and screening the total daily flow of 3.3 million gallons per day. On the million-gallon basis 30 cu.

ft. of wet screenings were obtained with the comparatively low moisture content of 81%. These were quite dry and in spadable condition as delivered by the bucket elevator. Dry solids amounted to 380 lbs. per million gallons, representing a removal of 21.3% of the total suspended solids from the crude sewage.

The screenings, gray in color, were a mixture of all sorts of sewage solids often containing considerable garbage. When spread on the ground, the screenings dried quite rapidly but with a pronounced foul odor in the immediate vicinity during the first three or four days drying. Flies bred profusely, indicating the necessity of treatment with a fly repellant while drying. At the present time the screenings are disposed on spoil land without any preliminary drying on beds. This method appears quite satisfactory.

Imhoff Tank Sludge, New Britain.

As drawn from the tank, this sludge was a thick black liquid having a tarry and somewhat offensive odor. Moisture content ranged from 84.8% to 92.6%, averaging 90%. There was no marked progressive loss in percentage of moisture with storage. From the dry basis tests, the various constituents of the sludge remained quite uniform throughout a storage period of about a year. Of the dry solids, 48.3% were mineral matter, 2.37% nitrogen, 14.3% plain ether extract and 19.5% acid ether extract. From volumetric measurements, combined with specific gravity and moisture tests, progressive digestion was noted with storage. Comparatively fresh sludge, after three months' storage, amounted to 72 cu. ft. per million gallons, which at the end of one year's storage was reduced to 46 cu. ft. Dry solids in the fresh sludge amounted to 470 lbs. per million gallons and after one year's storage to 322 lbs. Comparing the sludge solids with the amount of dry solids removed by the Imhoff tank, as shown by the suspended solids tests, the digestion of solids amounted to 36% after one year's storage.

With regard to moisture, mineral matter and nitrogen content, the Imhoff tank sludge at New Britain was almost identical with that obtained at Worcester, Mass., and Baltimore, Md. It is particularly interesting to note the very small difference in the

nitrogen content of these sludges, that at New Britain being 2.37%, Worcester 2.63% and Baltimore 2.75%.

At New Britain, the sludge dewatered very readily on drying beds. In one of the experiments during the summer the sludge was applied to a depth of twelve inches on the beds and was removed in spadable condition after two days' drying.

Secondary Tank Sludge, New Britain.

This sludge was obtained from plain sedimentation of the sprinkling filter effluent. The retention period in the tank was about one hour. The sludge was very similar in appearance, though noticeably more putrescible than the Imhoff tank sludge. There was but little difference in chemical composition of these two sludges. The tank was cleaned at intervals of from two weeks to two months, and therefore comparatively little sludge digestion would be expected. The dry solids recovered in the sludge were practically identical in amount with that removed from the filter effluent after passage through the tank. The dry solids recovered in the sludge amounted to 383 lbs. per million gallons, the suspended solids removed from the filter effluent to 380 lbs. per million gallons. The volume of wet sludge per million gallons sewage amounted to 94 cu. ft., this being about 20% greater than that from the Imhoff tank.

The sludge dewatered readily on sludge drying beds, but in actual practice it could be returned to the digestion chamber of the Imhoff tank and allowed to digest with that sludge prior to drying on beds.

Miles Acid Sludge, New Britain.

This was a rather thick, gray, greasy liquid with a pronounced foul odor. The moisture content averaged 95%. Averages on the dry basis were, nitrogen 3.1%, plain ether extract 21.6%, acid ether extract 30.3%.

A peculiar feature of the Miles acid sludge was its low dry solids content. The suspended solids tests on the sewage influent and effluent showed that the dry suspended solids removed from the sewage amounted to 767 lbs. per million gallons, while

the dry solids in the sludge were only 308 lbs. per million gallons, or 40.1% of the suspended solids removed from the sewage. There may have been some sludge digestion, but in view of the germicidal action of the acid and the absence of any gas bubbles rising to the surface of the tank, digestion, if any, must have been very slight. It is very probable that the dissolving action of the acid removed considerable of the suspended solids from the sewage, these passing off in solution in the effluent and not being recovered in the sludge. This would seem to be borne out by the iron determinations. The weighted average of all the Miles acid runs showed that the effluent contained 7.8% more iron than the influent, and while iron precipitates could be observed in the influent they were not observed in the effluent, being obviously in the dissolved form in the latter. The increase in iron content was traced to the action of the acid in attacking iron piping in the tank, parts of which were completely eaten away.

Another indication of the solvent action of the acid on suspended matter is by comparison with the results from the Imhoff tank. This removed 44.8% of the suspended matter and 25.8% of the organic nitrogen from the sewage, very little of the organic nitrogen changing to the ammonia form. The Miles acid process, on the other hand, removed 76.5% of the suspended solids, and as judged by the Imhoff tank removals, we would expect a removal of 44% of organic nitrogen. The actual removal of organic nitrogen, however, was only 7.3%, the effluent containing 92.7% of that in the crude sewage. We can account for this in no other way than by the solvent action of the acid on some of the suspended solids which prevented their precipitation.

The Miles acid sludge dried very slowly and with considerable odor on well-drained sludge beds.

Plain Sedimentation and Lime Treatment, South Manchester.

The tank retention period for both treatments was approximately four hours. Lime dosage was 0.2 gram per liter or 1660 lbs. per million gallons. From the standpoint of sewage purification, there was very little difference between these two treat-

ments, but in several respects the sludges were quite dissimilar.

Lime treatment produced about three and three quarters times as much sludge as plain sedimentation, the figures per million gallons being 607 cu. ft. and 162 cu. ft. respectively. The dry solids in the sludge were in about the same proportion, lime treatment producing 1760 lbs. per million gallons, plain sedimentation 455 lbs. Nitrogen concentration, however, was considerably higher in the plain sedimentation than in the limed sludge, the figures being 4.62% and 1.48% respectively. At the same time there was but little difference in the total amount of nitrogen recovered in the sludges per million gallons of sewage, lime treatment producing 26 lbs. and plain sedimentation 21 lbs. The difference in concentration is obviously due to the large amount of non-nitrogenous precipitates from lime treatment.

Activated Sludge, New Britain.

At the present time activated sludge is the most interesting of all sewage sludges on account of its possible utilization as a fertilizer base and also on account of the difficulty experienced in economically dewatering it. But little attention, however, has been given to some phases of the actual derivation of this sludge, and a brief discussion of these may be helpful in our understanding of the changes which take place in it.

With the exception of chemically precipitated sludges, sewage sludges are the result of the removal of suspended matter from the sewage. Activated sludge, however, in our opinion, is derived from some dissolved as well as the suspended matter, and if this is true it will explain some things in connection with the digestion of activated sludge and fixation of nitrogen from the air by certain sludge organisms which heretofore have not been satisfactorily accounted for.

In relation to the precipitation of dissolved organic matter into the sludge, the following figures are rather suggestive. Based upon the results from the Imhoff tank an 80% removal of suspended solids from the sewage would effect a removal of 46% of organic nitrogen. Actually, however, with about 80% removal of suspended solids by the activated sludge process we find a

corresponding removal of nearly 70% of organic nitrogen, or about 52% greater than the expected removal if the organic nitrogen were derived entirely from the suspended solids. Digestion or oxidation may account for some of this extra removal, but it seems much more likely that it is due to the assimilation of the dissolved organic nitrogen by the sludge organisms.

Taking the figures for oxygen consumed, we would expect, with 80% removal of suspended solids, 39% removal in the oxygen consumed. Actually, however, we find that the activated sludge process effects a removal of 65% in the oxygen consumed figure with 80% removal of suspended solids. In this case, also, oxidation and digestion may account for some of this removal but it seems more logical to assume that the assimilation of organic matter originally in the dissolved form in the sewage is responsible for the high reduction in the oxygen consumed figure.

The question of removal of dissolved organic matter can, of course, be settled quickly by comparing amounts and removals of matter in solution and suspension as well as total constituents, but unfortunately all the data at hand give results on total constituents in the sewages and effluents, and no attempt has been made to segregate them into the dissolved and suspended forms. If studies along these lines were available, our knowledge of this phase of the activated sludge process would be much more definite than it is now.

If we admit, however, that dissolved organic matter is removed from the sewage, it seems logical to assume that it has been assimilated by the sludge organisms as part of their food supply. This would very naturally affect computations pertaining to sludge digestion. If we base these computations on the removal of suspended solids only from the sewage, we find a very low percentage of digestion, the figures for Chicago and New Britain being 5.0% and 5.5% respectively, and from the intense biologic action in the sludge we would naturally expect digestion of sludge solids to be considerably greater.

Further, the question of digestion is important from the standpoint of fixation of nitrogen from the air by certain sludge organisms, some investigators having found that some of the

organisms often present in activated sludge actually possess the power of fixing nitrogen from the air. In judging fixation, a nitrogen balance is computed and if the amount of nitrogen recovered is less than the input, it has been customary to assume that there has been no fixation of nitrogen from the air. However, it is still quite possible that there may have been some fixation, but that the digestion has been so great as to offset the recovery of nitrogen from the sewage and the atmosphere. It is interesting in this connection to note that while digestion, both at Chicago and New Britain, amounted to about 5% of the suspended solids removed from the sewage, the actual loss of nitrogen at Chicago was greater than 30% and at New Britain amounted to 20%. If we attribute this loss to digestion, as seems logical, we must conclude that the percentage digestion cannot be computed from the suspended solids alone but that allowance must also be made for the dissolved solids assimilated by the sludge organisms.

As removed from the settling tank at New Britain, the activated sludge was usually reddish brown in color, due to the iron in the crude sewage. During prolonged periods of low iron content in the sewage, the sludge was gray in color, not unlike the slime characteristic of sprinkling filters receiving purely domestic sewage. The sludge was well flocculated but contained a noticeable amount of grit and coarser solids, such as pieces of paper and vegetables. These latter no doubt were due to the fact that the sewage was not screened prior to activation. As wasted from the settling tank, the sludge was found to be quite light, with a specific gravity of 1.004. Moisture content was very high, averaging 99.56%. About two thirds of the dry solids were volatile. Nitrogen content was comparatively low as compared with most activated sludges, averaging 4.1%. Plain ether extract amounted to 13.0%, acid ether extract 19.3%. A comparatively large volume of sludge was produced, averaging 22 100 gallons, or 2 950 cu. ft. per million gallons sewage. Dry solids, however, were comparatively low, averaging 810 lbs. per million gallons sewage.

The most effective treatment and disposal of activated sludge is by no means a settled question, and considerable ex-

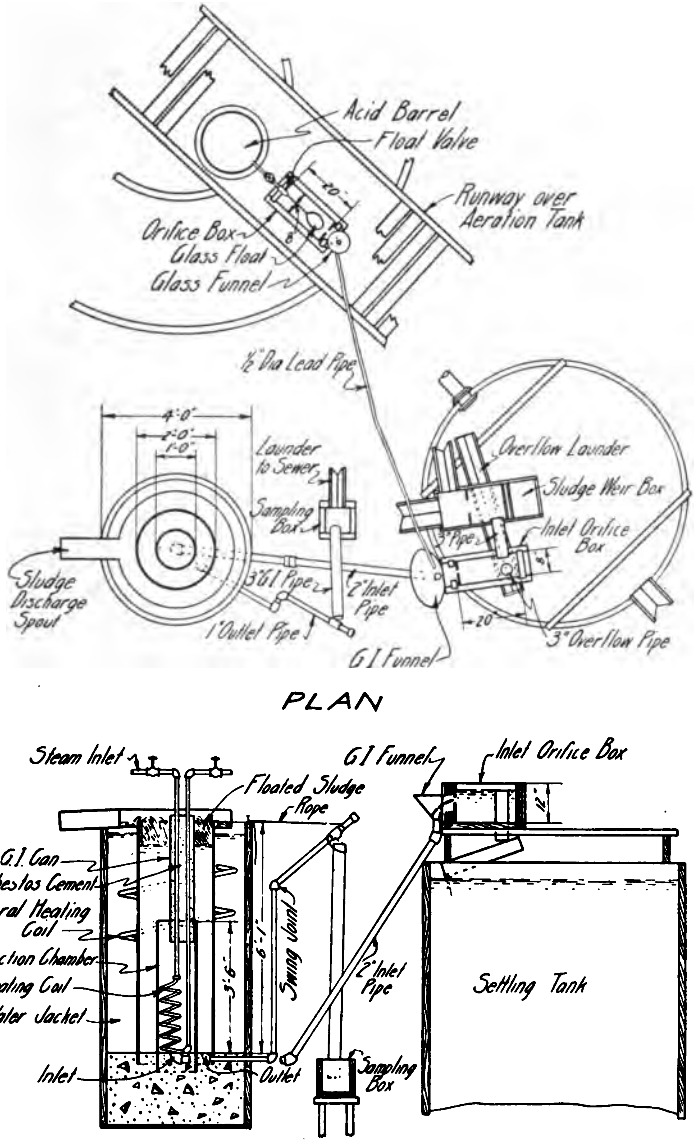

FIG. 1 — ACID HEAT FLOTATION PLANT.

perimental work is still being done on this problem, particular attention being given to preliminary processes which will dewater the sludge sufficiently to make subsequent treatment feasible and economical. In this connection, a recent process, acid heat flotation, was quite thoroughly tested at New Britain through the courtesy of the Dorr Co., of New York City, and a brief description of the plant and summary of results may be of interest.

THE ACID HEAT FLOTATION PROCESS.

The process consists essentially of first adding acid to the sludge and then heating the mixture. With proper design and operation, the results are twofold: first, the actual contraction of the sludge particles, and second, the flotation of these particles to the surface of the tank, where further dewatering and contraction takes place.

In the tests at New Britain both sludge and acid were fed from constant head orifices to a large funnel discharging into the inlet pipe of the flotation unit. (Fig. 1 & Fig. 2.) This unit was a galvanized iron tank 6.5 ft. deep and 2 ft. in diameter, set inside a four foot diameter wooden tank. Concentric with the other tanks and at the bottom was a small galvanized iron tank 3.5 ft. high and 1 ft. in diameter, forming a small reaction chamber. A small spiral coil, fed with live steam, was placed in this chamber. The inlet to the unit was through the bottom of the reaction chamber, the sludge flowing upward past the heating coil, the effluent being taken out at the bottom of the tank outside the reaction chamber. After heating, the sludge particles continued to float to the surface, overflowing into a collecting launder which discharged into a cart. (Fig. 3.) The unit as described was operated on the continuous flow principle, treating the sludge at a rate of 4 150 gallons per day or 173 gallons per hour. During the last five consecutive days of the flotation tests, the operation of the process was practically uninterrupted.

Average results over the entire testing period of about two and a half weeks were briefly as follows: The moisture content was reduced from 99.55% to 88.2%, the volume of sludge being reduced to one twenty-sixth, or 3.8% of the original volume.

The lowest moisture content for a daily composite sample of the floated sludge was 84.5%. On the dry basis, ammonia nitrogen averaged 5.85% and acid ether extract 16.2%. The average specific gravity of the floated sludge was 1.03. Of the total sus-

FIG. 2 — VIEW OF ACID FLOTATION PLANT.

pended solids in the influent sludge, 78.6% were recovered in the floated sludge, the remainder passing off in the effluent. Of the ammonia nitrogen input, 76% were recovered in the floated sludge and of the total iron input, 79%. These recoveries were not as high as would be desirable, but considering the experimental nature of the flotation unit, which was the first fairly large installation of its kind, perfect design and operation were not to be ex-

pected. The unit, furthermore, was operated 16 out of the 24 hours per day by unskilled labor. Due to these causes, there were times when considerable amounts of suspended matter were present in the effluent, which lowered the amounts of recovered constituents in the floated sludge. In spite of unfavorable conditions, however, the effluents were for the most part quite clear and often contained less than 100 p.p.m. of suspended solids, the lowest recorded being 55 p.p.m. Turbidities as low as 20

FIG. 3 — FLOATED ACTIVATED SLUDGE.

were often noted. In this particular effluent the suspended solids were approximately three times the turbidity, indicating that the suspended matter was quite heavy. Particles of grit and pieces of paper were, in fact, plainly visible in samples of the effluent. With a properly designed and operated plant, an effluent containing not more than 100 p.p.m. suspended solids might be expected and recovery of suspended solids and nitrogen in the floated sludge should be well over 90%.

Conditions at New Britain required the following operating rates: retention period in reaction chamber, 8 minutes; temperature of effluent 30 Co which was 150 C above that of the influent sludge; acid dosage, 1 c.c. H_2SO_4, sp.gr. 1.84, per gallon of sludge.

The acid was usually applied in a 2% solution. Qualitative experiments indicated that both acid and heat were necessary, as neither alone produced proper flotation.

The floated sludge dewatered very readily when spread on rather hard impervious ground to depths varying from four to

FIG. 4 — FLOATED SLUDGE ON DRYING BED

sixteen inches, dehydration cracks appearing in all piles within twenty-four hours. (Fig. 4.) The following moisture contents summarize the results of drying several cartloads of floated sludge in this manner.

Influent sludge, 99.4% moisture; floated sludge, 89.2%; 1 day drying, 77.1%; 2 days drying, 66.5%; 3 days drying, 59.7%; 3 weeks drying, 26.4%.

Most of the drying occurred during the first three or four days and was due largely to the drainage of water from the sludge. Evaporation of moisture seemed to predominate after that time The result of these experiments was conclusive that the activated sludge could be concentrated and dewatered by the acid heat flotation process sufficiently to render it amenable to drying on beds. This would render the final drying, either by direct or indirect heat, considerably less expensive than for filter press sludge. It is only fair, however, to assume that filter press sludge could be dried equally well on beds, so that the saving in cost of heat drying between the two sludges is more apparent than real.

Other Methods of Sludge Dewatering.

Drying on beds is the most common form of sludge treatment, but unfortunately this simple and economical method cannot be used for all sludges or in all localities. From our observation, grit, screenings, the sludges from settling, septic or Imhoff tanks usually dry readily to a spadable consistency. Some limed sludges also dewater satisfactorily on sludge beds, but with others clogging of the beds, apparently by lime soaps, is quite a problem. With Miles acid sludge, severe clogging of the beds took place. Untreated activated sludge, due to its rather gelatinous nature, quickly formed an impervious deposit on the surface of the sludge beds and the amount of drainage from the sludge was negligible.

Centrifuges have been successfully employed on sedimentation sludges in Germany, and experiments with the Basco ter Mer continuous centrifuge were made on the Milwaukee activated sludge. A low moisture cake, less than 80%, was obtained, but about half of the suspended matter was lost in the effluent. As this would result in undesirable pyramiding of the sludge if returned to the aëration tank, this method is not regarded as entirely satisfactory.

Filter presses have been successfully used to dewater limed sludges at several large plants in this country. Considerable work has also been done in filter pressing activated sludge, best results being obtained by acidifying the sludge prior to pressing. This method has produced sludge cake with as low a moisture

content at 75%, but rather cumbersome operation and expense of treatment are serious disadvantages. As to the relative merits of sludge flotation and filter pressing, we believe that the flotation process is much simpler to operate and very probably more economical than filter pressing, although the latter process will produce a sludge of somewhat lower moisture content. This last feature loses its importance, however, if the sludge is to be further dewatered on drying beds prior to heat drying.

At Milwaukee, in the early part of 1918, experiments were made by acidifying and settling activated sludge, reducing the moisture content in the sludge to about 91%. This method was apparently unsatisfactory, as no attempt was made to develop it into a practical and workable process.

The Maclachlan process, which is very recent, consists of burning sulphur, and forcing the fumes, mixed with live steam, through activated sludge. This process is being used at Houston, Texas, as a conditioner of the sludge prior to filter pressing, although the sludge, after treatment, is apparently amenable to drying on sludge beds. From the reports available, it appears that the process reduces the moisture content of the sludge from 98% to 95%, which is not as good as the results obtained with the other processes mentioned above. No data is given as to the percentage of suspended matter recovered in the sludge or the character of the effluent.

SUITABILITY OF VARIOUS SLUDGES FOR FERTILIZER BASE.

The concentration of ammonia nitrogen is the main criterion which determines the suitability of sludges for fertilizer base. Authorities quite uniformly agree that with less than 3% of nitrogen in the dried material, sludges are practically of no economic value as fertilizer. The Imhoff sludge tank at Baltimore, however, is a rather notable exception to this rule, as this sludge has been sold for fertilizer on the nitrogen basis, which usually was somewhat below 3%. At Rochester, too, the farmers are willing to pay sufficient to cover dewatering the sludge and haul it five or six miles for direct use on the land.

At New Britain, an interesting experiment was tried with the screenings. A plot of ground about three acres in area was sown to grass and fertilized with wet screenings applied in a thin layer. A surprisingly even and heavy growth resulted. For a number of years this same ground had been similarly sown but not fertilized and only sparse and patchy growths obtained. There was practically no odor or flies from the screenings and the results were so promising that the Superintendent of the Sewage Disposal Plant intends to make further attempts to utilize the screenings for fertilizer during the next planting season.

At New Britain also, considerable sludge is obtained from the sand beds, which up to the present time were dosed with raw sewage. The sludge was air dried and attempts were made over a number of years to use if for fertilizer. These, however, were unsuccessful and the present method of sludge disposal is by filling in spoil land.

Of the sludges here considered, however, we can dismiss as unsuitable for fertilizer base those from the grit chamber, Imhoff tank, and secondary sedimentation tank at New Britain and lime treatment at South Manchester, leaving only the activated and Miles acid sludges at New Britain and plain sedimentation at South Manchester as being possibly suitable for this purpose. Of these three sludges, the activated sludge, after acid heat flotation, had the highest nitrogen concentration, 5.85%. Plain sedimentation had 4.62% and the Miles acid 3.1%. The high nitrogen concentration in the plain sedimentation sludge is rather unusual for this type of sludge, but may be accounted for by the fact that the raw sewage contained considerable dye wastes, some of which had as much as 1 600 p.p.m. organic nitrogen.

Our experiments furnish some rather interesting data as to the varying nitrogen concentration of different sludges derived from the same sewage. Comparing the Imhoff tank and Miles acid sludges at New Britain, we find that the total amount of nitrogen per million gallons sewage in the former to be 11.1 lbs. and in the latter 9.6 lbs., yet the nitrogen concentration is greater in the Miles acid than in the Imhoff tank sludge. This is attributed to the solvent action of the acid on some of the sewage solids, preventing their precipitation into the sludge and thus resulting

in somewhat higher concentration of those substances actually in the sludge. Thus at New Britain, we have the anomaly in the Miles acid process of very small removal of nitrogen from the sewage but a relatively high nitrogen concentration in the sludge.

The reverse of this action is well illustrated on the South Manchester sludges. For example, the lime treatment sludge contained, in the form of lime precipitates, considerable extraneous matter other than sewage solids, so that we find the concentration of the actual sewage solids in the sludge to be proportionately reduced by the addition of these extraneous solids. Thus, while the nitrogen concentration of the plain sedimentation sludge amounted to 4.62%, that of the limed sludge was 1.48%, with a total recovery of nitrogen per million gallons sewage of 21 and 26 lbs. respectively.

Activated sludge at New Britain contained about three times as much nitrogen per million gallons sewage than either the Imhoff tank or Miles acid sludges. The more complete removal of suspended solids by the activated sludge process cannot be regarded as sufficient explanation for this circumstance, and it is our opinion that the high nitrogen concentration in the activated sludge is due to the assimilation of dissolved organic matter from the sewage by the sludge organisms and perhaps some fixation.

The suitability of sludge for fertilizer base is affected by factors other than the nitrogen concentration, such as availability of the nitrogen for plant food, the amount of phosphoric acid, the effect of fats and other chemical constituents of the sludge. Of the sludges here considered, however, the activated sludge appears to be the most promising for successful utilization as a fertilizer base.

Suitability of Various Sludges for Fat Recovery.

In general, sludges containing less than 15% fats are not considered suitable for fat or grease recovery. This, however, is a rather indefinite statement since varying amounts of fats are obtained depending upon the method used in making the analysis. Untreated sludge gives one result and sludges neutralized with sulphuric acid or treated with an excess of the acid give somewhat different results, due of course, to the action of

the acid on the saponified fats, and it is questionable whether or not these should be included. If fats are to be recovered at all, however, it is only natural to assume that the most complete recovery possible is meant, and for this purpose, as at Bradford, England, the sludge would be acidified before extracting the fats. In this case, therefore, the most important test would be the acidified ether extract and the present discussion assumes that sludges containing more than 15% acidified ether extract are tentatively suitable for fat recovery. With the exception of the grit, and possibly the screenings, all the sludges here considered contained more than 15% acid ether extract, the highest being from the grit chamber scum, which contained 66.5%. Plain sedimentation at South Manchester contained 37.5% and the Miles acid at New Britain 30.3%. Imhoff tank, secondary sedimentation tank and activated sludge each contained approximately 20% acid ether extract. Under present market conditions, it is doubtful if the extraction of fats from sludges of ordinary domestic sewages can be economically accomplished even with a concentration of over 15% acid ether extract. For certain industrial wastes and extraordinary sewages, such as at Bradford, England, fat extraction might be profitable. It has been stated, however, that one of the advantages of the Miles acid process is that the sludge is much more suitable for fat extraction than other sewage sludges, mainly because of its higher fat concentration. At New Britain, while the concentration of fats was higher in the Miles acid sludge than in the Imhoff or activated sludge, in actual operation after drying the sludges it is quite possible that there would not be any great difference in the suitability of these sludges for fat extraction due to concentration. As to the Miles acid sludge being superior to the other New Britain sludges, this is at least doubtful, even if sewage treatment is to be viewed from the standpoint of fat recovery rather than character of effluent. There can be no question that Imhoff tank treatment is considerably simpler and cheaper than Miles acid treatment, yet we find that Imhoff tank sludge, after three months storage, contained 67.2 lbs. plain ether extract per million gallons sewage while the Miles acid sludge contained 65.5 lbs. As for the acid ether extract, the Imhoff tank sludge contained 91.5 lbs. per mil-

lion gallons sewage and the Miles acid 93.4 lbs. The fat content of the activated sludge was almost double that from either the Imhoff tank or Miles acid, plain ether extract being 105.3 lbs. and acid ether extract 156.2 lbs. per million gallons sewage. As far as ultimate fat content is concerned, there is but little difference between the Miles acid and Imhoff tank sludges, while the activated sludge contains considerably more than either, in spite of the fact that the concentration in the Miles acid sludge is about 30% greater than in either of the other two.

SUMMARY.

In general, our experience in Connecticut is that where area is available, as at New Britain, air drying and final disposal on spoil land is the simplest and most economical method of handling the sludges from plain sedimentation, Imhoff tanks, secondary sedimentation tanks and perhaps lime treatment. It is true that more or less offensive accumulations of sludge would be developed, which, under certain conditions, would be a nuisance, but better and more expensive disposal would only be warranted by the assurance of recovery values that will, in part, offset the increased cost. The outlook for this, with the sludges just mentioned, is, however, not very promising.

Wet screenings, when applied to the land for fertilizing purposes, gave surprisingly good results. The experiment, however, was not carried far enough to be conclusive, and more information is necessary to determine how feasible it is.

For most limed sludges, filter pressing would probably be necessary. These sludges, apparently, do not offer much hope of successful treatment for either fertilizer purposes or other utilization.

A practical and economical method of dewatering Miles acid sludge was not developed. The preëminence of this method of treatment for producing a sludge particularly suitable for fat extraction was not shown.

Activated sludge, after acid heat flotation, air drying and heat drying would be readily adaptable for use as a fertilizer base. In the dewatering of activated sludge we believe that acid

heat flotation possesses certain advantages, such as simplicity of operation, elimination of filter pressing and saving in cost of final heat drying. It probably will not reduce the moisture content as much as either filter pressing or centrifuging, but apparently it will be cheaper than either of these methods.

For localities which require complete inoffensive disposal of sludge, irrespective of cost, Imhoff tank sludge, activated sludge and Miles acid sludge could be dried and degreased and undoubtedly recovery values sufficient to cover part of the cost of treatment obtained. Existing conditions at each locality would decide the method of treatment to be adopted. Where only partial treatment of sewage is necessary, economy would indicate selection of the method producing an effluent and sludge similar to those from the Imhoff tank. Where a greater degree of purification is required, then activated sludge or the Imhoff sprinkling filter system, either with or without recently developed modifications, would be selected.

Vol. IX MARCH, 1922 No. 3

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

SPECIAL FEATURES AND HANDLING OF "COST-PLUS" CONTRACT AT A SOUTHERN UNIVERSITY.

BY THOMAS C. ATWOOD,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

(Presented January 25, 1922).

THERE are many forms of "cost-plus" contracts, and while the purpose of the present paper is to discuss but one of those, it may not be amiss to allude to some of the others and especially to the reasons why they are held in disfavor by many people in order to show the reasons for certain of the provisions in the form I bring to your attention tonight.

The original form of contract is, of course, the straight "cost-plus" form, that is, the owner pays the entire cost of the project plus a certain percentage of that cost. This was open to the principal objection that there was no incentive to the contractor to hold the cost of the work down as much as possible, beyond the incentive provided by his own conscience and by his desire to earn a good reputation for doing this kind of work economically. Unfortunately there is a popular superstition more or less prevalent that contractors have no conscience while the natural tendency of owners to change and increase the amount of work to be done usually resulted in larger expenditures than originally contemplated, so that the best intentioned contractor usually found himself prevented from showing an attrac-

* Of T. C. Atwood Organization, Chapel Hill, N. C.

tive looking final estimate; and the comparison of the original and final estimates is what the average owner makes, with scant consideration of the cost of extra work he, himself, has ordered. Coupled with this trouble is the tendency of the contractor to make a close estimate in the first place, due to his desire to get the job, which often times depends upon this point.

Out of these troubles grew the "cost plus fixed fee" contract and this was claimed to eliminate the incentive on the part of the contractor to increase the cost so as to increase his profit, and did so, but did not permit the contractor to hold the work down to that originally contemplated, and was often times unsatisfactory to the owner because he found his final cost greater than he expected; and to the contractor because he did not receive a fair return on the value of the work he was finally required to do.

Then came various forms of guarantee in which the contractor agreed to assume part or all of the cost, if this ran above the estimate, while expecting to receive a greater or less share of the savings if the cost ran below the estimate.

This immediately introduced our old friend "extra work" in a virulent form and the last state of that man was little, if any, better than the first.

We may take it as an axiom in construction work that no contract is really satisfactory to either side unless the contractor makes money. In searching for the ideal form of contract, then, for any particular case, (and we should realize that no one form is universally applicable) we should aspire to find one which will allow the owner to secure his completed work at the time desired and at the lowest cost for the quality of work required, and which shall at the same time secure to the contractor a fair return on his stock in trade, whether the latter consists of capital, equipment or organization.

To come now to the case in point, the Trustees of the University of North Carolina were suddenly confronted with the problem of spending some $1 500 000 in buildings and other improvements. I say suddenly, because within a few days near the close of the last regular session, the legislature appropriated this sum and also abolished the State Building Commission

which had up to that time handled the construction work for all state institutions and threw each institution upon its own resources. The Trustees appointed an unusually able Building Committee which desired to proceed at once with the work as the need of increased facilities was great.

The program which I suggested to them seemed to make the correct analysis of the situation and they engaged me to carry it out. This program was, in brief, first to organize a force of architects and engineers to design the work on the ground and supervise its construction and second to let the entire work to a capable contracting firm on some form of cost plus contract and to get them started just as soon as the first plans could be prepared.

The form of contract selected was a modification of the "cost plus fixed fee" and was selected for the following reasons:

1. It was desired to start construction at once without waiting for preparation of plans and specifications and letting of lump sum contracts.

2. The construction was to be in a small town of less than 1 500 normal population with little available labor, and to have two or more contractors fighting each other for labor would be unfortunate.

3. There was no housing available for the construction forces, and as this must be constructed it could be done most economically under direct ownership of the University and remain for future work.

4. The introduction of a large construction force into a small country town was fraught with dangers which could best be controlled under such a form of contract.

5. It was desired to control the speed of progress in order to secure the buildings when most desired. The most recent building constructed at the University had been delayed for many months because it was let on a lump sum basis in a falling market and it was to the advantage of the contractor to delay it.

On the other hand there was a very real objection to what was termed the "wasteful cost-plus war time contracts" and the problem was to produce a form of contract which would meet the necessities of the case and yet avoid the objection stated above.

The form adopted is given herewith:

AGREEMENT.

This Agreement, made this 17th day of June, 1921, by and between the Trustees of Building Committee of the University of North Carolina, of Chapel Hill, N. C. (hereinafter called the Owner) and T. C. Thompson & Brothers of Charlotte, N. C., (hereinafter called the Contractor) Witnesseth: — That the parties agree as follows:

ARTICLE 1.

CONTRACTOR TO FURNISH.

The contractor shall furnish a skilled organization and shall carry on the work of construction of college classroom buildings, dormitories, dwellings for members of the faculty and such others as may be designated and the overhauling, changing or repairing of any buildings, and any other structures which the Owner may require, all to be located at Chapel Hill, N. C., and shall provide sufficient supervision from his main office to insure efficient and economical handling of the work.

ARTICLE 2.

PLANS AND SUPERVISION.

The Owner has appointed T. C. Atwood, Engineer, as his Executive Agent on all matters pertaining to this contract and all matters involving expenditures are to be approved by him or members of his organization acting within the scope of the authority delegated to them, before the orders are given or expenditures made.

The various structures are to be built, added to or repaired, in accordance with plans and specifications prepared by the T. C. Atwood Organization and all work is to be done under the supervision of this organization.

ARTICLE 3.

FINANCIAL.

The Owner will advance from time to time the funds necessary to carry on the work and the Contractor shall render strict account of all expenditures and shall submit a weekly report showing a balanced financial statement with paid vouchers supporting all expenditures.

All orders and contracts for labor and material placed by the Contractor shall be placed by him as agent for the Owner.

The Owner is to receive the benefit of all discounts, drawbacks, rebates, insurance dividends, unpaid wages and all similar items tending to reduce the cost of the work.

ARTICLE 4.

GUARANTEED ESTIMATES.

As soon as the plans and specifications for any structure are sufficiently completed, the contractor shall make and submit to the Committee an estimate of the total anticipated cost of the structure and shall guarantee that the total cost of the structure, insofar as shown by the plans and specifications on which the estimate is based, shall not exceed the estimate given. This estimate shall be submitted to the Engineer of the Owner for approval. In case of disagreement a third party shall be agreed upon whose decision shall be final and binding on both parties. The expense of employing this third party shall be borne equally by the Contractor and the Committee. Should the cost exceed the estimate approved or finally agreed upon, such excess cost of the structure shall be borne by the contractor up to the amount of his fee upon this structure.

ARTICLE 5.

LIENS.

The Contractor shall indemnify and save harmless the Owner from laborers' and mechanics' liens arising out of the work to be performed under this contract.

ARTICLE 6.

BOND.

The Contractor shall furnish a fidelity bond in the amount of twenty-five thousand dollars ($25 000) insuring the faithful performance of the various provisions of this contract and this bond shall be approved by the Owner. The premium on the bond will be paid by the Owner.

ARTICLE 7.

TRAVELLING EXPENSE.

Whenever necessary in the judgment of the Owner, travelling expense to the job one way will be allowed to men in the job organization, to be paid after satisfactory service. Return traveling expense will not be allowed.

ARTICLE 8.

FEE.

For his services the contractor shall receive the lump sum fee of ..... based on the completed value of work of $1 100 000 or a proportionate fee should the total value of completed work be less than this sum. If, on the other hand, the value of completed work be greater than $1 100 000 an additional fee of ..... shall be paid for each $100 000 additional value, no fee being paid for smaller additions than $100 000 to the main sum. Fees shall be payable monthly on the basis of the value of work done during the preceding month compared to the total. Ten percent. of the fee may be retained by the Owner until the satisfactory completion of the job.

ARTICLE 9.

FEE INCLUDES.

The fee paid to the contractor shall include his compensation and all expense to which he is subjected, except the cost of the job organization. This fee to the contractor will include his home office expense, including salaries, travelling expense, telephone and telegraph charges. Any special service required of the contractor's main office by the Owner shall be allowed as an extra expense. The regular service to be furnished by the Contractor's main office shall, however, include the following: All work necessary to establish the job office as a going organization; the setting up of approved systems of accounting and cost keeping; the services of his employment and personnel department in supplying the job with any necessary labor not secured locally; the services of his purchasing department in the purchase of materials whenever this is requested by the Owner; the purchase of all materials, however, to be subject to the approval of the Owner; the service of his estimating department in preparing estimates of the various structures; the visiting of the job by a superintendent at least once every two weeks; the visiting of the job by executive of the contractor at least once every month; the visiting of the job by a chief accountant at least once every two months.

ARTICLE 10.

TERMINATION OF EMPLOYMENT.

The employment of the Contractor may be terminated at any time by the Owner ten days after written notice to this effect has been mailed to his home office. In such case the Contractor shall use his best effort to turn over to the Owner all property and records in the best possible shape.

The Contractor shall be entitled to receive such proportion of the total fee as the sum of the expenditure at the date of termination, plus bills due and payable at that date, bear to the total estimated expenditure on his portion of the work, subject to the provisions of Article 8.

ARTICLE 11.

ACCESS TO RECORDS.

The Contractor shall permit the Owner free access at all times to all records, correspondence, calculations and similar papers relating to the work and all records shall remain the property of the Owner.

ARTICLE 12.

INSURANCE.

The Owner will secure insurance covering loss by fire and tornado on materials and uncompleted buildings and against liability for injuries to the persons and property of employees and the public.

ARTICLE 13.

SUB-CONTRACTS.

It is understood that the intent of this contract is to reduce the number of sub-contracts to a minimum. The placing of sub-contracts is to be approved by the Owner. The right is reserved by the Owner to place any sub-contracts independently of the Contractor.

IN WITNESS WHEREOF:

The said parties to these presents have hereunto set their hands and seals the day and year first above written.

(Signatures)

You will notice several special points regarding this contract. First, it is a "cost plus fixed fee" contract, based on a certain fixed expenditure with fee reduced proportionately for a lesser expenditure. Second: Provision is made for increasing the expenditure by securing a subsidiary fixed fee for each additional $100 000 of added expenditure. Thus the State is protected against payment of the full fee if unforeseen conditions require the amount expended to be materially reduced while the contractor is protected against being required to make largely increased expenditures without compensation. The contractor, it is true, may be required to expend $99 000 without added fee, but this is only an increase of 9 percent. in the principal sum and is not unreasonable. To allow an added fee for smaller sums would be practically a return to the straight "cost plus a percentage" contract which it was expressly desired to avoid. Third: it is provided that before beginning work on each structure an estimate of its cost shall be prepared and agreed upon between the contractor and the engineer of the Committee with provision for arbitration in case of disagreement, and the contractor shall guarantee this estimate to the full amount of his fee on each structure. This, you will observe, gives the State the benefit of a reasonably close approximation of cost in advance on each structure and also provides the necessary incentive for economical work on the part of the contractor.

It is true that this requires a considerable degree of mutual confidence between the contractor and engineer, but this has come to be recognized more and more of late years as an extremely desirable feature of construction work. In the present case half

of the total expenditure is now covered by these guaranteed estimates and in no case has there been any thought of the necessity of resorting to arbitration, all estimates having been mutually agreed upon with little difficulty and the respect of each side for the other has been constantly strengthened.

Fourth: A Bond is required. This was not originally contemplated, but when I went over the contract with the Attorney General, he thought it best to call for a bond principally because it is the custom for all public contracts to require one, this of course being due to the fact that the majority of such contracts are of the lump sum variety. In this case the bond instead of being the ordinary construction bond was restricted to a " fidelity " bond in the sum of $25 000, merely to provide for proper handling of business, the necessary money for the carrying on of this work being advanced to the contractor by the University. The unusual nature of this bond is shown by the fact that the bonding company had no appropriate blank and it was necessary to take a " personal " bond blank and alter it to cover the case.

Fifth: It is clearly stated just what we would do in the way of allowance for travelling expense, this being allowed only to men in the job organization and only one way, and this only in case we admitted the necessity. So far there have been but few cases in which travel expense has been allowed. The railroad fares of labor it was necessary to import has been advanced as usual, but later deducted from the wages due and we have had no difficulty in getting labor. This gives you an idea of how nearly we are getting back to normal.

Sixth: The contract clearly states that the fee paid to the contractor includes not only his profit, but also all expense to which he is subjected except the cost of the job organization. It covers his home office expense including salaries, travelling expense, telephone and telegraph charges and specifies in considerable detail the work and travelling which is expected of the home office force.

I have handled a great deal of " cost-plus " work in the last few years, and have found that there are generally more petty annoyances in the home office expense accounts and greater

difficulty in checking them up than in any other one thing on the job, and determined to eliminate this cause of friction. By specifying clearly the minimum number of trips to be made by members of the home office organization, this item could be readily approximated for putting in the bid and the question as to whether too many trips are being made does not arise.

The telephone and telegraph expense is small, but it is slightly disconcerting to find some subordinate in the home office sending numerous long telegrams or submitting heavy long distance telephone charges in regard to materials which will not be purchased for weeks or months and on which the mail would be sufficiently quick and as a rule more satisfactory.

Seventh: Termination of Employment. Provision is made for terminating the employment of the Contractor at any time on ten days notice. Nothing is said about termination for cause and this omission was made after due thought. With the clause as it reads the Contractor can be discharged at any time without the necessity of giving reasons or making troublesome explanations which may form the basis of financial claims or even of law suits. The terms of settlement are made a part of the contract so as to avoid claims for anticipated profits on the uncompleted part of the work. It is true this method of termination puts a powerful weapon in the hands of the Owner but the Contractor knew in advance the men with whom he had to deal, and besides the Owner will always be reluctant to make a change in contractors as the trouble and expense of such a move is sure to be great and to be undertaken only as a last resort.

Considering now the contract as a whole, you must not imagine that it was accepted by all concerned without the most searching scrutiny and the most careful consideration.

The Trustees Building Committee consists of the Governor, ex-officio, the Secretary of State, as active chairman, the President and Business Manager of the University, one of the principal lawyers of the State, one of the noted bankers of the State, a successful real estate operator and builder, the head of the Budget Commission, and a faculty representative. There are no better men in the State for such a purpose and they devoted a two day session to the examination of the proposed form of contract.

I took it on to Raleigh and submitted it to the Attorney General and the Governor. All, especially the Committee, were skeptical and while they admitted that the "cost-plus" form of contract was the only one suited to the conditions, they felt that it would be impossible to write one which would suit their various objections. This form, however, after careful examination, they approved with scarcely a change.

The next step was to advertise for bids and to my mind this was the crucial moment. If the contractors refused to bid on this form our efforts were in vain. On the day set, we received 28 bids, two of which were irregular, but the remainder bid on the contract exactly as written and without a protest. The list of bidders included some of the largest and best known firms in the East, and all seemed not only willing but anxious to undertake the work on these terms. The price bid varied from $40 000 to $80 000 or a fee of about 4% to 8%.

The list of bidders included such firms as the Turner Construction Co., H. D. Watts Construction Co., Foundation Company of New York, James Stewart & Co., H. K. Ferguson & Co., Fiske-Carter Construction Co., Dupont Engineering Co. and Stone & Webster.

One of the principal firms doing "cost-plus" work refused to bid on the ground that they might be forced to the position of guaranteeing an estimate lower than they thought the work could be done for, but this fear was not expressed by any of the other contractors.

The contract was let to T. C. Thompson & Brothers of Charlotte, N. C., although they were not the low bidders, but were one of the lowest and presented qualifications which seemed to the Committee to make them best suited for the work. They started at once and have completed to date sixteen dwelling houses and many small jobs and have four dormitories well under way.

The methods of handling this work have been thoroughly worked out and are given below: —

A. Purchasing.

The contractor is required to secure the authorization of the Engineer before making any purchase amounting to $100 or over. Smaller purchases he is allowed to make without prior authority but must submit these bills with the others, so no purchase escapes scrutiny. A special form of authorization is used, which I designed some years ago on similar work and have since used exclusively. It provides spaces for the following essential points:

1. Description of article to be purchased.
2. Bids received per unit and total.
3. Delivery offered.
4. Point of delivery, that is, whether f.o.b. job or where.
5. Recommendation of contractor as to which bid is most advantageous and why.
6. Signature.
7. Approval of Engineer.

This you will notice places on file all the needed information on a single sheet in a form easily referred to.

The question frequently arises why was a certain article purchased from the firm and in the manner it was. This is easily looked up in the file of purchase authorizations without recourse to the contractor's file of bids and again comparing them.

It is sometimes the case that the Engineer disagrees with the contractor by reason of more complete knowledge of the necessities of the case and decides to order from a different firm, perhaps at an increased price. If so, the record is clear and complete and the responsibility properly fixed.

B. Accounting.

The contractor is required to hand in each week a balanced financial statement, showing all expenditures made to date, backed up by vouchers.

This shows the state of the finances, but of course does not show the commitments nor the way in which the job is progressing as compared with the estimated cost. The latter is shown by periodical statements which show the cost to date,

plus the estimated cost to complete. Daily cost sheets made by the cost clerk are sent to the engineer's office by noon of each day, showing the unit labor cost on the principal items for the previous day, thus giving an opportunity to continually compare actual with estimated labor cost and take remedial steps before it is too late.

C. Employment of labor.

Standard rates for the different classes of labor were set at the outset and have been adhered to so far with little deviation. Common labor is paid 20c per hour, carpenters 50c to 60c and brick masons 75c. Over time is paid for at the same rate as regular time. The labor camp is run on a contract basis, the man in charge of the camp being paid $5.00 per week for each colored man boarded and $6.00 per week for each white man. This amount is deducted from the wages. Colored labor is housed in a separate camp from white. The colored labor is of the regular shiftless, slow, easy going kind usually found in the South, happy and care-free, ready to work hard if the proper singing leader is provided, but preferring to loaf rather than to work any day. A sharp lookout has to be kept for labor agents from other towns trying to get our men to leave. There are laws in North Carolina making this a hazardous occupation and more than once I have called upon the Mayor to see that a certain party ceased his flattering, but annoying attentions. The old way used to be to waylay the offender and beat him up, but this method, simple and direct though it be, seems to be falling into disfavor.

D. Inspection.

The work is carefully supervised by a resident civil engineer and one or two inspectors. There is, of course, less need of detailed inspection than on a lump sum contract, but I have never seen the construction job of any kind where an intelligent inspector was out of place and unnecessary, and most good contractors feel the same way.

E. Working out of contract.

Our paths have not always been strewn with roses, but on the whole everything has worked out admirably. There has been no difficulty in agreeing upon guaranteed estimates and in the case of the jobs which have been finished, the records show costs to run very closely with the estimates. The only exception is in the carpenter labor which has run high, showing that the efficiency of this class of labor has not returned to normal. Recent figures on the dormitories show that they are running close to the estimated costs with a possible saving of about 3%.

So far our experiment seems to be working satisfactorily and all hands are working faithfully together to make this continue to the end.

DISCUSSION.

W. D. HENDERSON*— I recently handled the supervision of a "cost-plus" contract which might be of interest. Incidentally it was a piece of work undertaken in the South — in South Carolina. This contract was with a large contracting concern, but was unusual in that it was not covered by the ordinary written form of contract. The owner said to the contractor — he knew him, by the way, and had worked with him before, — "You go ahead with this work". It was agreed what his fee should be, but the contractor advanced no funds whatever for any of the construction work. The owner placed a sum of money in his own bank and gave the contractor the privilege of drawing on that for his immediate expenses. Incidentally this sum was sufficient to cover approximately one month's work. At the end of one month the contractor submitted a statement in which he showed the amounts of his total expenditures for the month. The fee which went to the contractor as compensation covered much the same items as Mr. Atwood has mentioned, except that some of the office expenses were billed, such for instance as stationery.

I have never known of another contract let that way.

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* 21 Woodard St., Newton Highlands, Mass.

Mr. Atwood — The question has been asked as to how bids were compared. The contractors all bid on the basis that the total work would cost $1 100 000, and their bids were a lump sum fee for doing that amount of work. If the total proved to be less than that they were paid pro rata. If more than that they got a certain additional fee which they also put in as a bid. If it didn't amount to $100 000 more they got nothing in addition.

For instance, if the fee was, say, $50 000 for $1 150 000 of work and $5 000 for each additional $100 000; suppose the work amounted to $1 270 000, they'd get $50 000 for $1 150 000, and $5 000 for the $125 000 more. They wouldn't get anything more than that unless they did $200 000 worth in excess, when they would get $10 000.

With reference to daily costs: We have a special cost clerk who goes around every day and sees how much work has been done and figures up what each of the main items would cost, — how much to lay brick or to lay up tile or per square foot of forms, — erecting the forms, — items like that. We started some brick work on one outside wall of one of the dormitories and the first day we got $33 per thousand labor cost, — it was special double course bond we used there. We got right after it and tried to get better methods and we got the price down to $20 or $22 per thousand. It gives us a chance to catch any excess labor cost every day.

MEMOIR OF DECEASED MEMBER.

RICHARD HUTCHINSON.*

RICHARD HUTCHINSON was born in Douglastown, N. B. on May 25, 1872. He was the only son of Ernest Hutchinson — a prominent lumber operator in northern New Brunswick — and Eliza Jane (Johnston) Hutchinson. His early education was obtained in the schools of Annapolis Valley and in Acadia College. At the age of eighteen, he came to the United States, taking a course at the Rhode Island Technical School, and later working in several shops in and about New York, prominent in different lines, with the definite purpose of getting a broad experience. In this way, he came early in 1894 to the Babcock & Wilcox Company, and entered the service in which — with the exception of about a year — he was to spend the remainder of his life. The first years were passed in the Engineering Department, where, beginning as a draughtsman, he afterward won promotion and found opportunity to demonstrate that capacity for affairs, accuracy and thoroughness which were his to a marked degree.

It was, however, in the field of engineering sales that Hutchinson's inclinations and talents found fullest scope. Transferred to the Company's Boston Office as salesman in 1899, he became its manager in 1910 and so continued until his death. Possessed of a keen analytical mind, resourcefulness and Scottish persistence, he was peculiarly definite in his objectives and steadfast in their pursuit: moreover he was a master of the art of clear and concise statement. Always alert, he never allowed himself to be stampeded. A business friend wrote of him, "He would analyze a prospect better than any man I ever knew. He would set down the factors that were in his favor and those that were against him and could generally figure out with mathe-

* Memoir prepared by I. E. Moultrop and R. E. Curtis.

matical exactness as to just why he should get the order or why it should go against him.—He could think of more logical reasons why a man should buy his boilers and of more reasons why they should not buy the other fellow's than any man in the selling game that I ever met."

Mr. Hutchinson was an enthusiastic yachtsman, finding in the sport not only recreation but opportunity for scientific study and experiment. First and last he owned quite a number of boats, both sail and power, racing several of the latter which he designed in long distance ocean contests. At the time of his death he was Commodore of the Boston Yacht Club. He was also a member of several other organizations, engineering and fraternal. His membership in this society dated from May 18, 1904.

He died on June 14, 1921, leaving a widow and one son.

Quiet and undemonstrative in manner, he was notably genial and loyal to those whom he favored with his friendship.

Vol. IX APRIL, 1922 No. 4

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

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ADDRESS AT THE ANNUAL MEETING.

By Robert Spurr Weston, President, Boston Society of Civil Engineers.

(March 15, 1922.)

Some Engineering Practices and Ideals.

My memory of the addresses of past presidents of this and other engineering societies is a complete covering of all phases of professional practice. There seems nothing left unsaid about what has gone before. On the other hand there is much new engineering food which needs rumination. Some of this is as yet so raw and so untried that it is unfit for mental refreshment, — some of it a hash of what has been served before under another name. I am therefore running the risk of seeming obviously trite on the one hand, or visionary on the other, in choosing as a subject, — "Some Engineering Practices and Ideals."

In discussing this subject, I shall hope to illustrate the individualistic and coöperative practices of engineers, and the ideals upon which they are based.

The term engineer can be used to describe a wide variety of callings, some of them commercial, some of them having only the remotest connection with true professional work, but for a while let us turn away from the ideas of running engines and machines, the measuring of energies, objects and values, and bear in mind the higher side of engineering, — the work of the scientific imagination, the grouping of images into a mental picture, the development of design by logical processes of thought, and the

realization of these in plans, specifications, in public support and in the finished work. In our minds at least, let us spell ourselves *ingeniers*, the mediaeval Latin term describing those who *ingeniate*.

Before the days of organized schooling for professional engineers, even as late as the days of the guild and the apprentice, great works were few, and were performed by a race of supermen, — men whose individual minds encompassed most of the engineering knowledge of their time; men who, by sheer force of intellect and character, and usually in spite of ignorant opposition and the lack of facilities, accomplished marvels in the way of raising the level of human living. No ordinary man could do what they did.

Consider for a moment the difficulties presented to the inventor of the first wheel, the first arch, the first aqueduct. Consider Cromwell's opposition at a later time to the recovery from the sea of England's best arable land by the early engineers.

In the 15th century, Leonardo Da Vinci was an illustrious example of the highly developed individualist. He was painter, sculptor, scientist, architect and engineer. He stood apart from his fellows like an isolated Monadnock, many-sided, strong, enduring and solitary. Engineering was but one facet of the gem of his personality, but on this side he was a master by the force of his own character, his hunger for truth, and his resourceful ability.

Consider Watt holding a spoon over the spout of a steaming kettle in his mother's kitchen. Consider his precocity in mathematics and science, his delicacy of body and his achievement after years of anxiety and labor, and with the help of Bolton, of the steam engine as a commercial machine. Consider his seeming universal knowledge and his eminence among inventors and discoverers of all time.

Consider the poor colliery fireman's child, George Stephenson, and the enormous development of his character and mind which resulted in the " Rocket " and the steam railway.

Also Brunel, who built the Great Eastern while he was also building his largest bridge, a dock, and personally supervising railway construction in India, Italy and England.

Among these examples of illustrious individuals, Leonardo Da Vinci may be considered as belonging to the monastic, the early English engineers to the aristocratic, and the modern engineer to the democratic type. It is of the growth of democracy in engineering through coöperation that I would speak further.

With the steam engine, the railway and the steel-screw ship came a demand for many engineers. There was more work than there were self-trained geniuses. The first recourse was to military engineers trained to some extent to build roads and bridges. For a while they sufficed, but the field broadened, the work grew and specialized. The military training no longer sufficed even for the superman, and electricity began its work in industry. It must not be forgotten, however, that with the development of the schooled engineer, certain natural characteristics of mind were not so highly developed among the general run. To illustrate by an aphorism from a note book of Leonardo Da Vinci, "When science put a knife — an artificial weapon — in man's hand, he lost the use of his nails — his natural weapon."

In Great Britain, the standardization of engineering by professional training began at Glasgow University in the 1830's, with Rankin, an early graduate, teaching all of the branches of the art a few years later, and in this country with the founding of Rensselaer Polytechnic Institute in 1826.

The first technical schools were simple affairs and were often expansions of Departments of Mathematics; but knowledge increased, libraries grew, practice ramified, and the profession began to specialize. The field grew too broad for men, even those of the genius type, to work alone, and the specialties multiplied.

At the beginning of the Great War, while some of the specialties called engineering lay in the field of commerce, and the dividing lines between specialties were faintly defined, many kinds of engineers had been named and had grouped themselves in numerous societies. I am inclined to believe that while this extreme specialization is partially the result of methods of thought and training, particularly in our technical schools, it has resulted mostly from the great diversity of jobs which the

engineer is asked to do, and the disinclination or the financial inability of the average student to prepare himself along broad lines.

There is quite a group of engineers who belong to a number of technical societies, and are difficult to classify. The best of these are the professional descendants of the early engineers. In their breadth of interest, they remind me of the remark of a dear old lady of wide experience who, in her 80's, is still active in good works. Being asked what was her church, she replied, "My father was a Baptist, my mother a Methodist, my husband a Congregationalist with strong leanings toward Unitarianism, while I am interested in Spiritualism, see good in Christian Science, and the Swedenborgians believe I could easily become one of them. Now will some one tell me where I belong?"

Many of this group divide their interests and energies and become ineffective thereby. They become discouraged by the number of contacts, — time-consuming and expensive, — which under present condition a broadening of interest demands. The more highly developed of this group, because of their greater energy, see vast problems in true perspective, and because of their wide connections are able to coördinate large undertakings. Even these leaders realize the handicap of present conditions, but for the others there must be coöperation or ineffectiveness.

Consider how the development from the individual to the social or coöperative type is paralleled by the evolution of animals. In the lowest forms of these, the amoeba, for example, a single cell performs the functions of locomotion, feeding, digestion and reproduction. Then we see developed in still higher forms, organs of locomotion; a mouth; digestive, circulatory and nervous systems; and specialized organs of reproduction. In lower forms, as in the European oyster, there is no sex differentiation, the parent being both male and female. Higher in the scale begins the differentiation of sex and the development of the higher faculties and the social instinct, most marked in the highest races of man.

Highest among insects are the ants and bees, and while we may not quite follow Mäterlinck to believing that bees are

perfect models for human communities, they do exhibit a high degree of coöperation with specialization, acting under the "spirit of the hive" for the greatest good of their community, and in doing so exhibit virtues of courage, self-sacrifice, affection, industry, thrift, contentment, cleanliness and chastity, which human beings might well emulate. Their only defect seems to be the lack of a spirit of service for others, as exemplified by the inhospitality of even the highest type of hive.

Likewise, the wolves, among the most intelligent of mammals, hunt in packs and achieve results impossible for the individual. Indeed, Kipling reminds us that even in the jungle where the weak and aged die violent deaths,

> "The strength of the pack is the wolf,
> And the strength of the wolf is the pack."

I am not one who believes that the engineer is indifferent to public service. In fact, in proportion to his opportunities and means, he has done his part. It is difficult for the engineers, few in number, to make an impression on a community dominated by larger groups, or to render personal service to society on the minimum living wage. It is only with the organized effort of the whole engineering group as a background that the work of the individual engineer can be placed in its right light before the public.

I have called your attention to coöperation by education, and by grouping into societies, but to bring into effect the mass action of engineers and technicians as a leavening force in society, and to do this without waste, coöperation of societies is necessary. This was the real reason for founding the Federation of American Engineering Societies, and the affiliations of local technical societies.

Many questions have been asked regarding the activities of the Federation of American Engineering Societies, and the value of supporting this new organization, — one year old last January.

I may not take time to describe the Federation, but feel sure that the failure of some members of this Society to contribute to its support is due in great part to a lack of sufficient acquaintance with the work which the Federation is doing.

Every effective social group in the country has taken to heart the moral of Aesop's fable of the wood cutter and the twigs, which illustrates the strength of union; and nearly all of these groups are represented in Washington more or less effectively. Many of these organizations are self-seeking, but we are proud that the Federation has held to a high ideal of service. Out of thirty important accomplishments of the first year, less than one fifth directly benefited engineers, and in this fifth are included the active support of bills for completing the topographical map of the United States, for commissioning sanitary engineers in the Public Health Service, for the reclassification of grades and compensations of engineers in public service, for licensing engineers in the states, the placing of more than 1 200 engineers in employment, and also the establishment in the public mind of the role which engineers play and should play in modern civilization, — none of which is entirely without benefit to the whole people.

The best accomplishment of the Federation, to my thinking, is the feeling engendered at the Capital that the Government has now a definite point of contact with the whole engineering profession, and engineers may be depended upon for unselfish public service, — to give without the expectation of getting.

Through the Federation, this Society has a new and efficient channel of communication with the Government, and we have already used this to express our opinion regarding matters of national importance. But it is of more importance to my mind in preventing unwise and abortive actions by the local societies on matters which affect the whole country. For example, the Federal Water Power Bill, in which our Society was interested, is now being carefully studied by the Federation, and this study should result in logical steps being taken which should lead to proper modifications of legislation. Had the matter been presented to the Government in the usual way by this society alone, it would not have met with the respectful consideration which it is now receiving.

The Boston Society of Civil Engineers has just voted to join the Affiliated Technical Societies of Boston, one practical advantage of which will be a sufficient reduction in expenses to

allow an increase in society activities including membership in the Federation. While this Society will undoubtedly have less freedom of action as a member of the Affiliation, here again should the benefits of coöperation outbalance its disadvantages. This new affiliation bears an analogous relation to its members and to New England to that the Federation bears to the member societies and the country.

While it is too soon to promise what this affiliation can accomplish, the desired ends have been set forth in an illuminating way by our Committee on Intersociety Relationships, and the movement should have the hearty support of every member.

By living in one house, different kinds of engineers should become more sociable and better acquainted, more tolerant of one another's ideas, make use of each other's special abilities more frequently, and become more familiar with the various applications of science to engineering and technology. Many engineers have a deep understanding of *things*, but often lead lives of disappointment. A frequent cause is their failure to understand *men* as well. In any human undertaking, human understandings are most important, and it is believed that by increasing contacts, individual members of the Affiliation will gain in this important respect. All of us desire a true appreciation of the merits of the engineer by the community, and to have his work better known.

While blatant advertising, especially by professional men, is distasteful, and it is far more important to be worth knowing than known, there are many who would profit greatly and contribute more to society by simply being neighborly and by elevating professional acquaintance to the high plane of friendship. In so doing, they would draw upon the great emotional reservoirs, the power of which we manipulators of material forces and things often fail to sense. In a friendship is found the highest type of service, and therein lies success.

If engineers coöperate by taking to heart the value of extending the limits of the personal relationship and the responsibility for service which it brings, I feel that we need show little interest in laws for the regulation of engineering practice, and codes of ethics would have only an educational value.

Self-sacrificing service is the highest form of coöperation and furthermore develops the highest type of engineer. This idea is as old as the Book of Tao and the supreme theme of the Sermon on the Mount. It is the only one which can develop the character of the engineer, and enable him to fulfill his destiny in his community, his country and his world. It can gain much strength through the incorporation of a democratic community of engineers. That the new Affiliation will prove to be such an organization is the hope of its promoters.

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THE ENGINEER IN THE TROPICS.

BY T. HOWARD BARNES.* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

"Then go away if you have to go,
Then go away if you will,
To again return you will always yearn
While the lamp is burning still.
You've drunk the Chagres Water
And the mango eaten free,
And, strange though it seems, 'twill haunt your dreams,
This Land of the Cocoanut-Tree."

— JAMES STANLEY GILBERT.

THE pure luxury of stretching at ease, book in hand, enveloped by a breeze tempered at eighty degrees, is a sensation not peculiar to any one clime. To avail of such, however, some part of each day, in three hundred out of the year, is possible only in the Tropical belt.

That some such compensation is deserved for bearing with the 'tween time ills no one will deny. No description can be phrased improving upon Gilbert's, of the worries and the pests of those siren shores. Not in vain had this Kipling of the Isthmus made his home where insect and malaria alternate with trade wind and moonlight through the palms, and his ready pen has wonderfully pictured one's conflicting sensations. He knew what it was to have to drive sluggish labor by day as well as to enjoy conviviality on a cool veranda after sunset. He had seen

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the dancing devils of a fever-stricken brain, likewise enjoyed the fun of a moonlight lobster hunt in the phosphorescent sea.

The newcomer frequently tells you very soon after arrival that he wants to get back home, things are different from what they were represented. However, he is under agreement to remain, as a usual thing, and remain he does, unless his temper is such as to make him useless to the enterprise, in which case he is shipped away and the loss is charged up to "contingencies."

FIG. 1.—"TO AGAIN RETURN YOU WILL ALWAYS YEARN."
NANCES CAY — ALMIRANTE BAY, PANAMA.

One might see him later, when the cold winds of December have arrived, and hear him tell of the wonderful days he left behind in the "Land of the Cocoanut Tree." He would like to go back, or thinks he would, and if he should go he would probably be better satisfied and perhaps make good. However, we don't take the risk. On the other hand, if our hero has sturdy blood and some resources within himself, he accepts the situation he finds himself in, works on, discovers that there are compensations, helps to finish up the job and then feels that he has earned a rest and a period of recreation. Then when such a one remembers the "Land of the Cocoanut Tree" he is fairly sure to go back when opportunity offers, a seasoned man who has made good, and commanding a salary of which he has proved himself worthy.

Tropics. — The tropics present many variations of climate due to elevation and rainfall distribution. One cannot imagine more equable June-like conditions than those prevailing along the cordillera of Central America. It is here that the capital cities are situated at elevations from 2 500 to 5 000 feet, where the temperature is seldom excessive. The seasons divide sharply here between wet and dry, this being the case thence down to the Pacific.

At sea level the temperatures rise higher and further meteorological phenomena caused by the sea are presented. On the Atlantic side of Central America combinations of Trade winds and land topography result in a chaotically distributed rainfall, without any well-marked dry season excepting in spots, or well back from the coast. In the West Indies and on the northern coast of South America, the above mentioned combinations are operative, being vitally affected by the direction of the coast line and the relation thereto of the mountain ranges. Here also seasonal divisions into wet and dry are quite sharp, and a rainfall varying from fifteen to one hundred and fifty inches or more is found. Where a distributed rainfall exists, it usually occasions a high humidity. Where such prevails one on arising at 5.30 is burdened with a damp cloth feeling and a temperature close to or at the perspiration point. One experiences quite the contrary sensation in the wet and dry season regions where the morning freshness is life-giving.

The physical benefit of this absence of humidity has its counterpart in a mental exhilaration which the mutations of the seasons bring about. I refer to the Spring awakening which follows the falling leaf of the dry season, so in contrast with the dead monotony of green jungle prevailing in the all-the-year-round damp regions.

Temperature vs. Tropical Construction. — Taken at its best, however, he figures ill who plans to conduct work in the Tropics along lines normal to the Temperate Zone.

Apart from the important phase of distance from base which adds to its complications, there are not only new people, new customs, new materials to utilize and conform to, but as well new prejudices, new diseases and new bugs — physical and psychological — to combat.

Roosevelt's account of his African trip pictures the great difference the hunter finds there, in contrast with Rocky Mountain conditions. In the latter, one rolls himself, clothes and all, in his blanket and falls asleep in the open, while under the dog star he must first divest himself of insect life and get under carefully drawn screens.

FIG. 2 — ONE WAY TO UTILIZE THE BURRO. — BUILDING VILLEROS DAM. COVENAS, COLOMBIA.

The same vexations and annoyances which roll off the surface on the Polar side of the Tropics take root and grow within their limits. Real troubles take on gigantic proportions while imaginary ones become tangible. The nervous system becomes unwontedly active just as the perspiratory one does, until the equilibrium of the overworked wires is upset. Also, as if always a malign influence must prevail, the liver grows torpid through the assumption of its work by the perspiratory system, and the old world is " sicklied o'er " by a jaundiced hue.

Personnel. — In selecting one's personnel, especially the one, two or more men at the head, great care should be exercised. Only those who have had previous Tropical experience, and who have demonstrated tact and resourcefulness should be entrusted with the execution of construction work in these neurotic climes.

Moreover, the men in these chief positions must be those who can with their own hands show the untrained laborers how to do their work, " Point the road to Heaven and lead the way."

As to Families. — We have heard the question argued back and forth, formerly more than now, as to the advisability of allowing families of employees to accompany them on Tropical engagements. One may sit down and convince the person who knows nothing about it that it is absolutely unwise to allow any wife, and especially the wife and children, to accompany her husband to the lower countries. On the other hand, observation has taught that as usual there is a golden mean. For a man with his family is living under normal conditions, and is more likely to remain so, provided his helpmate is of the right sort. Being thus placed under normal conditions, he will help in keeping those around him so. With some family life existing in the settlement, social amenities are possible, affording a certain feminine atmosphere for those unaccompanied by their families and for the unattached youth, which wards off gross tendencies.

It has been left for the Britisher to teach us the lesson of making a home where we go. One who is entering Tropical life for the first time, to carry out any extensive operation, will find it profitable to visit some of the British possessions, Jamaica, Trinidad, Demerara, etc., to observe what an atmosphere can be produced by persistence in one's home habits. Every one is recommended to read Flandrau's " Viva Mexico," in this connection, especially that delightful chapter about the Trawnbeigh Family.

The writer remembers the wonderfully refreshing sight of a few years ago, following a period of some duration in localities where the white woman in the colony was more of a rarity, to witness the normalcy produced by sports and games like bowling, provided for the employees and their families on the Canal Zone. Sober thought has passed judgment that the sensible, sane, busy woman is a desirable acquisition to her husband and the colony. The woman is no worse a gossip than the man, nor as bad. She usually has not enough to do, hence the stipulation that she must be busy. It is reasonable to believe that if a clean-cut grass sward with a neat hedge of Tropical plants surrounding a dwelling

in the midst of an isolated banana, cane or chocolate farm, will produce a feeling of at-homeness, how much more will that feeling be increased with the house-wife and her little ones within view thereabouts.

Sanitation. — So much has been written on this theme as to seem to make it unnecessary, indeed presumptuous, to add anything here. It is easy to forget, however, and there is one point out of all the good advice regarding clearing, ditching,

FIG. 3 — VILLEROS DAM. SO FAR BUILT BY BURROS. COVENAS, COLOMBIA.

housing, screening, water-supply, diet, etc. I would like to emphasize; namely :— the ninety per cent. advantage and the ten per cent. cost of the benefit usually obtainable by ditching off surface waters and letting in the sun.

I recall one situation which at first looked impossible to deal with. The picture presented was a row of straggling structures on the beach, a sand bar thrown up by the waters of the bay. These houses were those of squatters, for the most part, with a few of the more pretentious ones located on regular lots. Back of the bar stretched acres of bush-covered flats, standing several inches deep in water at all times, the terra firma being mud, underlaid by sand at a depth of a few inches to ten feet. Mosquitoes were present in myriads, increased, of course, by the un-

regulated rain water receptacles standing about the dwelling, but for the most part bred in the swamp at the rear. The situation appeared really desperate but it took only a few hundred dollars for clearing off the bush and trees, a few hundred more to run simple ditches, with a small sum for burning up the trash at an opportune time when the rain had forgotten to fall. Between showers the sun dried up the remnant of standing water not carried to the ditches, and left the ground absorptive instead of saturated.

Of course the rain water receptacles were done away with and a simple water system was installed. The net result was the abolishment of the mosquitoes. It must be cautioned, in passing, that a transformation like this is not self-perpetuating, and this case was not an exception to the rule. Indifferent hands had charge for a while, but the work was at a later period taken over and properly and cheaply maintained, and remains to-day as a happy illustration of the soundness of the civil engineer's guiding rule of "directing the great sources of power in nature, for the use and benefit of man."

Labor. — The method of securing labor is one dependent very much upon the size of the job. Anything of great magnitude justifies a labor department, with various ramifications, including agents for enlisting the men, a construction force for housing, and a prosecution of welfare work after the men have been landed on the job. To the enterprises of smaller volume, and this is the usual one, serious questions are opened up. If one is at a distance from large cities, he is situated between good luck and ill; good, because he is free from the city worker, who, while more versatile than the countryman, is too likely to foment trouble; and ill, because the man from the sod, it may be from coffee farm, cane plantation, cattle pasture, or elsewhere, has not the advantage of any previous construction training.

We will assume, therefore, that our source of labor is the surrounding country. Some attraction or inducement must be offered. Probably an advance payment is requisite. In many countries this may be made in such legal form that the individual is obliged to work it out. Assuming that our intentions toward our labor are fair—and they must be or we should never start in—

we secure the best possible representative we can, a citizen of the country, to execute this important trust.

The creation of a village feeling must now be borne in mind. We provide proper housing, and the feeding facilities. The latter are dependent upon the habits of the people. Almost always, especially at the start, the allotment of a cook and helper for each group of — say — twenty-five men, works well.

FIG. 4 — NATIVE HOUSE BUILT WITHOUT NAILS. COLOMBIA.

Provision must also be made for family life. Some men will want to bring their women, and accommodations should be furnished so that they can. Early establishment of a Commissary store is imperative. This should be run for helping the labor supply and not for its direct profit from sales. Luxuries, if carried, may yield whatever profit one chooses to fix, but necessaries of life should be cheap. A reputation for cheap living is to be desired. It soon spreads abroad, though not as rapidly as does a reputation for a contrary condition.

It is a mooted question about selling rum. The writer does not favor it and has the practice of some long-headed citizens of Latin-American countries to sustain him. If strong drink is obtainable at points within reach, I would always limit sales on the works to beer and wine, together with soft drinks.

Housing and Health. — Simple housing, maintenance of cleanliness and a surety of good food at a fixed price, are rules that apply to all help in the out-of-the-way place, where our engineer is likely to find himself. Gradations in all of these items, according to classes of help, are of course to be understood; but each and every class must be looked out for. My experience is that it pays to feed and to house well, sufficiently well to constitute an attraction. It is commonly found that existing conditions in the region round about are at a low standard, and one's instinctive feeling inclines him to set up a system as suggested above, which commends itself to common sense and is good business in the long run.

I could cite instances where the furnishing of slightly superior accommodations has proved to be the key to success in economically carrying out work that was very special. The advantage offered by these dwellings held the men and prevented an otherwise big turnover of help, which would have entailed very vexatious results in the continued breaking in of new labor.

A regime which stops short of coddling, while carrying out the above ideas of looking out for one's labor, is wise from all points of view. Frequently, also, the construction work is for an industrial establishment and the taking of rather extra pains in the personnel has its additional value in building up a supply for the operating force.

Housing and mess accommodations for the imported employees should be made flexible. The writer makes use of a type of house which is adapted for housekeeping, and at the same time available for single men. It is thus possible to house a maximum number of employees at the start with a minimum of effort being diverted to this branch of the work.

Also it will usually be found that a general mess run at a fixed price by the company is advisable. Resources which later are at hand to permit individual housekeeping and real homes to be formed are too much lacking for that purpose at first.

It may be interesting here to mention one or two details of the headquarter houses which the writer observes in their construction. First, elevation of the floor seven or more feet above the ground, so as to permit utilizing the space below for laundry,

rough storage, playing, drying clothes, etc. Second, admission of air to rooms from two sides. Third, provision of a sitting veranda rendered practically rain proof by wall construction up to height of window sills and by wide overhang of roof. The same, or even less money, sometimes spent for an open veranda on three or four sides of the house will afford more satisfaction in securing one such sitting veranda on which furniture may remain at all times without damage. Of course, in some few

FIG. 5 — TYPE OF HEADQUARTERS HOUSE ADAPTED FOR BACHELORS OR FAMILY. ANT PROOF BASE—ELEVATED FLOOR—WIDE EAVES. COVENAS, COLOMBIA.

localities high winds will cause any veranda to become for the time useless. Indeed, such winds may entail the installing of glazed sash instead of simple blinds or jalousies generally sufficing. I am, of course, assuming that the screening of all outside openings is admitted as necessary.

A wholesome dread should prevail of any reputation for unhealthfulness attaching to the enterprise. Circumstances may arise through carelessness, or ignorance, or out of a clear sky, which plant the seeds of panic in the minds of employees, especially the white imported ones. The writer was a close-by observer of the near-panic on the Canal Zone in 1905, caused by the outbreak and continuance of yellow fever. He has also seen

elsewhere the morale of this class of employees badly shattered by the injudicious magnifying of the danger of infection of filaria.

As to the labor within the country, they also fight shy of an enterprise labelled with a reputation for feeding poorly, or having sickly surroundings. We may plan our very best, with reasonable housing, food, medical care, etc., and then find some influence, very likely unmerited, is working against us.

Another phase of the attitude of the country labor must often be reckoned with. It is its conception of what Hospitals are for. We are surprised to find that they think of a Hospital as a place to die in. Yet some of us, not so old, remember when going to the Hospital was equivalent in our minds to taking a last chance instead of our present conception of the Hospital as being our first hope and natural recourse.

The early accession of a good doctor is a necessity. He can give the common labor treatment right from the start, and gain their confidence in him and in his institutions. They are patient and appreciative of medical attention, and through this ever ready ministration are gradually brought to feel what a Hospital is really for. Then as to the imported employees, the doctor stands ready to say "Pooh" to a whim, and to afford proper service for real ills.

Making the Most of Labor. — Every effort should be bent to engage the labor on task work. They are accustomed to this, they enjoy working by fits and starts, and ordinarily lay off for a whole day during the week, with a half one every now and then. Their usual day consists of getting out at sunrise, swinging a machete until mid-day, or later, returning to their shelter and swinging in the hammock, enjoying the ministration of whatever feminine hand holds sway for the rest of the day.

It most often happens that a tasking of the labor cannot be arranged. In this case it will be found all the more valuable to do as much machine work as possible. If their attention is taken up by following the regular sound of a machine, especially if by diligence the pace may be slackened up for the last half hour of the day, they forget in the meantime their own troubles and save your nerves.

The wise foreman will avail of the above and of all possible means to secure a return from the untrained labor. Granted that the latter has strength, that he has come to work, fortified by something more than a drink of water sweetened by country sugar (" panela " or " dulce ") then demands upon him for performance can be hopefully made, backed up by frequent reminder, and at times that powerful weapon, namely, sarcasm, which is far more effective than invective and leaves the boss the master of the situation. Failing all these, the imposition of a fine for absolute disregard for duty is a method often necessary to adopt, and one received in a strangely submissive way when it is really merited.

Materials. — The maintenance of a flow of materials in proper order and well in advance of necessity is imperative. Not only does the economy of construction depend on this in a direct way, but, as well, such economy is affected in an unlooked for indirect way. This is no less than an avoidance of a letting down in the morale, which, strange as it may seem, actually happens when repeated failures in the arrival of materials take place. It is actually true that any conscientious superintendent having his work all laid out by schedule becomes convinced that the base of supplies is being manipulated in a perfectly rotten way; no one is thinking of him and his work, otherwise why don't " they " send along materials. Then on top of it all, along comes a consignment of materials consisting of roofing, when columns are what he is looking for. It needs a patient character, one reasonable and with sufficient imagination to bear in mind the numberless causes for delays at the home port not to become misanthropic. This being the case, how diligent should the home office be to " keep the home fires burning."

Correspondence. — All correspondence should be conducted with a thought of the assistance and encouragement which it will be. Reports in proper form tell the history of construction as it goes along, but a weekly letter back and forth between the home office and the job is also needed to supplement this information. In all this the home office should observe super care to avoid any criticism in the least undeserved, sometimes even forgetting that which may seem merited.

Overhead. — The high cost of overhead will surprise anyone undertaking for the first time this long-distance work. This should not stagger one, however, for if the labor is untrained but rightly handled, even though the number of foremen, engineers, timekeepers, etc., needed to make the best use of this working force mounts up to a high proportion of the total payroll, it will be found that a less proportion so applied will reduce the effectiveness of the laboring body, and prove to be poor economy.

FIG. 6 — THE JOB NEARLY DONE. LA UNION WHARF, EL SALVADOR, C. A. M.

When one has been accustomed to carry in mind four or six per cent. as about the right proportion of overhead to labor cost, it comes as a surprise, in fact almost consternation, to be confronted with the large figures which will be found under circumstances with which we are dealing. In other words, overhead cost bears no true relation to the question of good or bad management in itself; and in most cases in the writer's experience, the cheapest construction has been accompanied by a very high overhead percentage. There could be cited one case where the percentage was above twenty, based upon the sum of both labor and material, with a resulting total cost which was perfectly satisfactory.

Courage Pills. — Doses for physical ills are a requisite. I have not gone into details of the necessary medical service, not that it should go unnoticed, but because I have considered it outside of the province of the layman and that sufficient had been published on this topic. Still, at the risk of entering into one detail of dosing in which doctors have disagreed, I am going to make a venture. This will be in the safe method, however, that of quoting someone else.

I refer to the dosing of quinine for avoiding or mitigating malarial infection. Two authorities from observation points a thousand miles apart, each in latitude ten degrees north, have vouchsafed as their judgment based upon many years' experience, that the most effective dose, where mosquitoes are prevalent and may not be eradicated, is from fifteen to twenty-five grains given once a week to each and every inhabitant. One of these medicos went so far as to affirm that, given autocratic authority, he would undertake to eradicate malaria over a country wide area by this means.

However, another kind of dosing is what I wish to call attention to. Proper letter-writing has been mentioned as one of the means of maintaining the courage of the distant personnel. And here let me strongly caution against the permitting of any auditor, either in the home office or the local one, to assume directly or by implication, by letter-writing or otherwise, the management or other executive functions in relation to the work. This is far from meaning that proper accounting should not be had, or that the maintaining of an independence between the accounting department and that of the construction should not be preserved. Neither does it mean that there is any reason why they should not work coöperatively for the good of the company. For, be it remembered, that the useful man, whether constructor or accountant, is he who at all times is loyal to the corporation or individual who is paying him his salary; and he has no right to put personal affairs above corporate ones. He must at all times judge his actions along the straight line maxim of doing what is best for his employer, or as usually stated " being a corporation man."

Granted that proper letters are doing their legitimate service, it must further be remembered that neither these nor any other means will substitute the effect which is to be had by the personal

FIG. 7 — FIGHTING THE JUNGLE. LEADING WATER TO PUERTO BARRIOS, GUATEMALA.

contact of home representative with the foreign personnel. The penalty for conducting either construction work or business at a long range entailed by a tropical location, is that visits may not be made at frequent intervals by the responsible head from the home office. This getting onto the job face to face with the fine fellows doing company work is nothing less than inspiring.

The long hours of the few men who lead the way, their overcoming of difficulties and their all-around balance are features to be appreciated only by being seen. If these qualities are non-existent then there should be a change in the personnel. At the same time the effect on the home office is just as productive of sanity as it is upon the organization at the other end.

Opportunities. — We are often asked what the opportunities are for employment in — well, generally the question ends in, "down where you go," or, "in South America." Distance always lends enchantment, and usually to the questioner there exists a mistiness as to advantages or their absence. The writer cannot relate from experience anything concerning those thriving, populous countries of South America, south of the Tropics, nor indeed of the Tropical Belt south of British Guiana. However, it may be understood as applying to these regions as well as to those farther north, that the engineer seeking employment should secure a position before starting. If he arrives on the scene without commission, seeking a job, he is put down as a tramp, and seldom wears off fully the first impression he gives.

In what has been stated hitherto, it is plain that the desirable engineer, and the one most likely to make good, will be the one with the most experience. His eyes have generally been opened to knowing that there is more than one way to accomplish a given thing. He is therefore inclined to look about for adjustment to local conditions and adapt means to ends. It must be remembered that we always have something to learn in construction matters from the people we find ourselves among.

In his environment of fresh viewpoints, unexpected opportunities for new application of materials and ideas arise. Distance from usual supplies inclined him to resort to the use of local ones in novel ways and justifies him in so doing. Difficulties in local transportation as well as freight cost lead up to innovations in construction. In these our engineer must fall back on his good judgment, not forgetting to call in his assistants for council. Herein lies his strength in undertaking the novel in construction, that those helping in the execution shall feel that the project is in part their own.

The same cautions hereinbefore expressed for maintaining the morale of the organization, apply also to the one in charge locally, as between him and his working force. Only one who is magnanimous with his own aids can hope to make complete success.

In these times when strong organizations are looking outside for opportunities for construction work, and when business and

FIG. 8—A PLACE TO GET WELL IN. THE QUIRIGUA HOSPITAL, GUATEMALA.

development concerns are evolving projects in which engineering design and construction form part, the engineer will find his best alliance to be in some such connection.

General. — It should be remembered for the consolation of any candidate for the Tropics that one cannot make over human nature, nor can he change the habits of the people. However gratifying it would be to play the reformer, one must be satisfied with something less than the ideal, be at times a little blind. So good an authority as Ben Franklin in speaking of personal character has told us that a benevolent gentleman will permit a few faults in himself so as to keep his friends in countenance. I think on the whole there are very few of us who have insufficient faults to prevent being forgiving in dealing with the people among

which we may be thrown. Too many Americans (United States citizens, I mean) forget that it is not for their health that they go to a foreign country but for greater reward in money, for adventure, perhaps, but in any case they were not invited to go there by the people of those countries, hence any display of superiority whether by word or by look must be studiously avoided. It is easy to speak the word " Greaser " or " Spiggoty," but don't do it, and what is more don't think it. The same qualities of frankness and sincerity which commend a person to children are what carry one through everywhere, and the Tropical world is not an exception to this.

Vol. IX JUNE, 1922 No. 6

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

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WHAT SHALL BE DONE TO SECURE BETTER CITY PLANNING?

BY GEO. H. NYE,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

(Presented May 17, 1922.)

WHAT is City Planning? The best definition I know is that of Mr. Nelson P. Lewis, who says, " City planning is simply the exercise of such foresight as will promote the orderly and sightly development of a city and its environs along rational lines, with due regard for health, amenity, and convenience for its commercial and industrial advancement."

Included in this definition are implied considerations for providing proper conditions for manufacturing, commerce and transportation; an adequate street system with sewers, water, light and power; suitable housing for the inhabitants; schools and other public buildings; parks, playgrounds and all recreational facilities.

These considerations call for consistent planning and lead to the so-called zoning ordinances to provide suitable living conditions for the shop and home. This subject is so large that it would require volumes to fully discuss the various features.

I do not propose to-night to speak of the " City Beautiful," of civic centers, parks and boulevards, or of the relative values of diagonal or gridiron layout of streets, or of the intricacies of the zoning ordinances.

* City Engineer. New Bedford, Mass.

In meetings which I have attended there has oftentimes been an attempt to cover too much ground, and too much time has also been devoted to advocating the desirability of systematic planning.

We may well save time by conceding the need of all these things and devote our time to a discussion of what seems to me to be our most urgent problem to-day, — the securing of a satisfactory street system. This is a fundamental requirement about which all other features may be built up. In our New England cities and towns street systems already exist and must be given due consideration, although it is seldom found possible to alter them radically.

It is the duty, however, of those holding official positions to see that, in the future growth of our cities, the mistakes of the past are not allowed to be repeated.

It will perhaps help us to visualize our present problem if we pause for a brief review of the history of the growth of the country which has resulted in conditions as we now find them.

The first settlers naturally located on the coast. There was before them a vast, unknown wilderness, populated by a hostile people. Behind them was the ocean, furnishing their only means of connection with the world that could supply them with the commodities which they could not themselves produce.

The settlements first spread along the shore and their principal means of communication was by water. Later these settlements spread back into the fertile river valleys and were reached by means of the old Indian trails which had been followed by the natives for unknown ages.

These trails were crooked and indirect, following the lines of least resistance, keeping on the ridges to avoid swamps, and turning sharply to cross lowland and streams by the shortest possible routes. The mode of travel was by foot or horseback, and roads as we know them did not exist at this time.

The people generally relied wholly on their own efforts for their existence, raising their own grain, meat, flax, and wool; hewing their own timber, and weaving their own cloth. When, later, this was proved to be a hardship and a wasteful method of production, we find little settlements growing about the good

harbors and at water-powers where small manufacturing, grist mills, saw mills, etc., were established and where those properly equipped for the purpose and devoting their whole time to these industries did the sawing, weaving, and similar tasks.

The workers in these small manufacturing plants located their homes in the immediate vicinity, and in those days short, narrow streets were opened for their use. A particularly good example of this type of development can be found in the old village of Marblehead.

Although the villages commenced to develop street systems, these were adapted only to the needs of that time when the distances traveled were short. The one fixed journey was usually the weekly trip to the church; then there were visits to the grist mill, the blacksmith shop, or the country store.

The trails from village to village were gradually improved and made passable for teams, but no very great development of these was made until 1800, when post roads were first established, usually by private enterprise. These privately owned roads were known as turnpikes. They were provided with toll gates and depended for their support upon the fees paid by the users of the roads. Some of these turnpikes still followed the old trails while others were laid out in absolutely straight lines, extending for long distances. Over such roads as these it was possible to ride by stage coach from Boston to Bristol Ferry in the remarkably short time of 31 hours, leaving Boston Tuesdays at 5 A.M., and arriving at Bristol at 12 M. on Wednesdays, where connection could be made for Newport. The fare for this trip was 25 shillings for each passenger, with an allowance of 14 pounds of baggage. The distance traveled was 55 miles.

While of course new roads have been built continually since that time, it is still true that the main roads through New England follow these old Indian trails, and it is this condition which confronts our State Highway Department to-day.

Long distance automobile and trucking traffic is now being moved over a system of roads developed originally for local use and wholly unsuited to modern needs. The officials of these departments will probably concede the great relief a few through roads, developed along the same lines as those on which our

railroads have been built, would be to the present congestion of our roads.

But our problem has to do with the cities, and I have mentioned the larger situation only because of its similarity.

In the older sections of our cities also we may still trace the location of some of these old trails and early local roads. These old road systems and streets, crooked, narrow, indirect, and entirely unsuited to their present day use, have been widened and added to by later generations and now form the business centers of some of our largest cities.

There are millions of dollars worth of property now located on these streets and the cost to-day of a general tearing down and relocating is prohibitive. Even in the case of conflagrations which have devastated large sections in some of our cities, comparatively few changes in the street system have resulted. A few streets have been widened, and here and there a new street put through or an old one extended.

It is visionary to expect to take our existing cities and rebuild them to meet modern conditions. The best we can do is to make such widenings and extensions as are absolutely necessary, and this does not properly fall under the section of city planning which I wish to consider. In these cases the need is urgent and the remedy usually apparent, and the question resolves itself into one of engineering and business, one of balancing known benefits to be derived with the cost of securing them. The relief afforded by this expedient is well illustrated by Figs. 1–4.

The larger and more difficult problem is to design and put into execution a plan for a proper growth of the cities as they now exist so that the newer sections will be free from the undesirable features of the old.

This question further resolves itself into two, one of design and one of accomplishment.

The first is largely the problem of the engineer, and is, I think, fairly easy of solution. In studying the needs of a city we should consider that in reality it is but a large and complete industrial plant, having facilities for carrying on the manufacturing and commerce of the people and furnishing them with homes and all suitable conveniences. Viewed in this light, the

proper layout of the plant does not seem to present a difficult or unusual problem, and is fairly an engineering one.

My method of procedure, assuming the usual case of a city or town already established with a considerable portion of the surrounding territory cut up with new streets and with scattered houses, would be substantially as follows:

FIG. 1.—N. W. CORNER UNION AND PURCHASE STREETS BEFORE WIDENING.

First secure an accurate topographical map of the district, totally ignoring the existing city, and on this lay out one or more ideal plans for the development of a city, taking advantage of all the natural features in locating the transportation system, manufacturing section, and business and residential districts.

Next secure a plan of the existing city with its actual transportation lines and various districts. Then, by superimposing one upon the other, we can readily see where glaring mistakes exist, if there are any such, and in making any changes due to

congestion of present street conditions we can more readily determine where and in what manner to make them in order to approach most closely the ideal condition. This method will prevent haphazard improvements which will be only local in their effect.

FIG. 2.—PURCHASE STREET AND UNION STREET (LOOKING NORTH) BEFORE WIDENING.

Probably the cost of changes of this kind would be so great that but few would be warranted except in the most congested sections. But as we approach the outskirts we can begin to approximate more clearly the ideal layout obtained by assuming the site of the city to be unoccupied. And as we get farther out we have a still freer hand and can, if necessary, re-locate railroads, waterfronts and main roads.

In other words, by a careful study of the needs of the city and the topography of the site we will be able by foresight to

develop a street system which will give an opportunity for much better living conditions in the newer sections of the city than can ever be expected in the old.

But it is much easier to conceive than to execute. We are not dealing with a free hand to locate streets wherever they may

FIG. 3. — PURCHASE ST. AT UNION (LOOKING SOUTH) AFTER WIDENING (1915).

be most needed. The land to be occupied by such streets is owned by private individuals, and I have found that each individual owner has ideas as to the manner in which his particular holding shall be developed, and as hardly any two owners desire the same thing, the matter usually results in a conflict of opinion between the authorities and the owners of various properties.

In the earlier development the villages were usually provided with streets which were fairly uniform, although narrow. Later, as the villages grew, the farms immediately surrounding

them were sold for building purposes. In my own city, and I think in others, the boundary lines of these various farms can be traced to-day by a series of breaks in the continuity of the streets; each farm having been subdivided irrespective of the streets located on the adjacent land.

FIG. 4. — PURCHASE ST. AT UNION (LOOKING NORTH) AFTER WIDENING (1915).

At this period these lands were usually sold in lots by the original owners, but during the latter part of the last century, when the cities had become much larger and were growing rapidly, largely with a foreign population, land companies were formed with offices in many cities. Their object was to purchase cheap farm land and cut-off land in the outskirts of the city and sell the same in small lots. The price paid for the whole was so low that these lots could be sold at an apparently reasonable figure and yet secure enormous profits to the owners.

These companies, comprised generally of men not living in the cities where their operations were carried on, were but little concerned in the interests of those cities and cut their holdings in a manner to yield the greatest profits to themselves. Each owner cut his own tract to suit his convenience, without regard to the continuity of streets or possibility of proper drainage, and the cities now have a condition to face which will cost them enormous sums of money to remedy.

The second part of our problem — that of accomplishment — is most clearly for our lawyers and law makers, who must furnish us the means to prevent improper development and for acquiring and preserving proper street locations in advance of the actual need of streets for travel; in other words, the means for securing an adequate method of permanency for a street plan for future needs.

Under the present laws I know of no way that this can be done except by the actual taking of the land required for street purposes under the right of eminent domain. If this is done, the taking becomes void in two years after its adoption unless entry, for the purpose of construction of the street, is actually made on each piece of land so taken. In case such action is allowed to lapse, every owner of land so taken, who has been actually injured through loss or use or opportunity for sale, is entitled to receive compensation from the city for such actual damage as he has suffered.

If entry is made within the prescribed time, however, no individual can get title to land so taken through a claim of adverse possession until the expiration of forty years. On the other hand, the city has become liable for the safe condition of the street so acquired for travel. This necessitates at least the clearing and grading of the street.

Such conditions, of course, preclude the possibility of cities securing many miles of streets on their outskirts which we all know will be required for their future growth. The streets are not required now, it would be most undesirable to destroy all the farms in the suburbs, and the cost would absolutely prevent such action if it were desired.

How then can we plan for the future if we cannot enforce the plan?

To revert to the early settlement of the country, one of the first acts of the colonists was to hold meetings and adopt a bill of rights, which is practically our constitution of to-day.

While the whole object of emigrating to this country was to secure freedom and liberty, the colonists recognized that there was no such thing as absolute liberty for the individual, but that all should consent to be governed by laws made by themselves for the best interests of the community as a whole. This idea is perhaps what is now termed the police power upon which the zoning ordinances are founded.

In this bill of rights was directly stated the right of the individual to acquire, possess and enjoy property, but the interests of the community were held superior to those of the individual. The public could dispossess the individual of his property for the public good upon proper compensation and by due process of law and for specific purposes. This may be called to-day the constitutional right.

All this, of course, was written at the time I have already recalled, when roads and present day conditions were nonexistent and unthought of, but is the most sacredly regarded of all our laws, and has come down to us at the present day practically unchanged. It is this constitution against which we stumble in all our attempts to provide a street plan for the future, and it may have to be amended to conform to modern conditions before we can obtain any effective method of carrying out a city plan.

In my opinion it is fundamentally true that the location of a street for the use of the public for all time is a public function and should not be determined by the selfish interests of an individual. Equally, the prospective location of a future street across certain lots, preventing the sale of the lots or their use for building, is a loss to the individual owner, suffered for the benefit of the public. If the right to so locate future streets is to be exercised, some fair method should be devised to compensate the individual for the actual loss thus suffered.

One method of accomplishing this object might be by so amending the laws relative to the laying out of streets as to allow

the municipalities to accept streets, paying damages therefor where they occur through destroying the salability or use of lots too small to be properly adjusted to the street location; and by removing the restriction of the loss of the layout unless entry is made for construction within a given period; and the requirement that the municipality be liable for the safe condition of such street for travel.

This would require the creation of a dual form of acceptance: The first action to secure only the location of the street, allowing present owners to use the land so taken for all purposes except such as would render the municipality liable for additional damages when it is actually taken for travel: and a section action taking such location for the actual opening of the street for the use of the public.

The state has recognized the need of some such provision and has provided machinery for this purpose in two forms, neither of which, in my opinion, accomplishes the purpose intended.

In the General Laws, chap. 41, sect. 70–73, every city and town of over 10 000 inhabitants is required to create a planning board. But that this is a half-hearted measure is evidenced by the fact that no penalty is prescribed for non-compliance with this mandatory law. That the law is not favorably considered is further evidenced by the fact that many cities and towns have refused to comply with it, and among them some that are keenly alive to the desirability of proper planning. The law is extremely weak in that it gives the planning boards no powers beyond advising the councils or selectmen of the municipalities. If such a planning board devised a complete plan and their plan was duly adopted by the municipal authorities, no municipality in the state could carry out the plan successfully for the reasons above stated.

The other medium for securing a proper plan is the Board of Survey,—General Laws, chap. 41, sect. 73–81. A perusal of this law at first gives the impression that here is the very thing sought, but at the end it gives the penalty for noncompliance which is a negative one and so weak that it renders the law valueless.

In accordance with this law, if an individual subdivides his land by streets and does not secure the approval of the local

board of survey, no register of deeds may record his plan, and no public improvement may ever be made on such street. This merely keeps the plan out of the registries, while the land can be readily conveyed by metes and bounds in a perfectly legal manner, the only result being that the public is deprived of the convenience of consulting the plan.

If a colony of houses were built on a group of streets not approved, I cannot conceive any municipality allowing a health nuisance to be developed in its midst through lack of proper water supply and sewerage, or that they would allow the requests of any considerable group of taxpayers and voters to go unheeded. The result would be that in the end the board must give its approval to the plan they at first rejected and furnish the public improvements.

The second section of this law provides a means whereby a municipality can study its needs and conditions and adopt a complete, desirable, and scientific plan for a system of streets, exactly in accordance with our highest aims. Even when this is done, however, an individual owning a small lot and not desiring a street across the same in accordance with the plan, can build directly within the limits of a proposed street; and the only penalty therefor is the inability of the authorities to put sewer, water or any public improvement in a street that he does not want to exist and which he himself has blocked by his building.

Such, then, is our situation to-day in this state. We all realize keenly the need for proper planning and its economic value. The engineers are capable of producing a reasonably good plan for the development outside the present built-up sections of the cities, securing for them the most desirable and economical location of streets and drainage.

On the other hand, I believe we are powerless to-day to put such a plan into effect under our present laws.

DISCUSSION.

Miss ELIZABETH M. HERLIHY.* This gathering here to-night brings joy to my heart. Too long has City Planning been hailed as a synonym for the City Beautiful. Too long have City Planners been assailed as sacrificing the economic for the æsthetic, the practical for the beautiful, utility for Utopia. The City Planning movement has been like a great ball of sunshine, poised more or less precariously on the edge of our municipal horizon, shrouded in a cloud of misunderstanding and distrust, appreciated by those close enough to see beyond the encircling shadows, but oftentimes misjudged by those outside the pale. Once those clouds of misunderstanding and distrust are pierced and dispelled by the cold, practical, analytical minds of our engineering populace, the effulgent rays of city planning principles, so long encased, will radiate and spread, bringing health and happiness into our homes; comfort, convenience and order into our daily lives; and progress and prosperity to our community.

To be entirely practical, — and I know that I must be if I am to find favor with my present audience,—I might say that all that has been said here to-night about unscientific development applies perhaps more specifically to Boston than it does to any other city in the United States. I feel that I am merely stating a fact, not voicing a criticism, when I say that the Boston of to-day, aside from its park system, is largely the result of haphazard development and unrelated growth.

I hesitate to say anything which appears like a criticism of our city, for I have more than ordinary love for it, and a more than ordinary appreciation of and admiration for its administrators, especially those with whom I have come in contact during my twelve years of municipal life. In fact, when I visit other cities, I come back firmly convinced that Boston has more natural advantages, is more logically developed, and is better governed than any other city in the world.

But the fact remains that Boston has not yet had a really thorough, painstaking, and farsighted study of its street problems in the big way in which other cities have approached the vital

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part of traffic reform. It is generally conceded that conditions attendant upon vehicular and pedestrian traffic are almost intolerable and yet the fact remains that, aside from certain street widenings and one-way street regulations which have acted merely as palliatives and in no sense as correctives, the first fundamental step in the adoption of a comprehensive street plan, designed to encourage and stimulate the growth and development of the city, is to be found in the recently authorized widening and extension of Stuart Street.

Boston was one of the first cities in America to adopt a comprehensive height of building law; it has certain regulations governing the area or proportion of lot to be occupied for building purposes; it has a building zone within which structures must be of practically fire-resisting material; it has silence zones about its hospitals and zones of quiet in certain sections during certain hours of the night; but it has absolutely no regulation governing the use or development of property outside of the police power, which is usually an unpleasant influence to invoke.

The division of the city into residential, commercial and industrial districts would, as we have been told here to-night, result in stabilizing property values, protecting residential areas and promoting industrial and commercial development.

At the same time it would afford a solution of the public garage question, which is one of the most imperative problems confronting the municipality to-day. His Honor the Mayor has to-day signed the order of the City Council accepting the provisions of the Legislative Act which prohibits the erection or maintenance of a garage for more than four cars on the same street as, and within 500 feet of, any building occupied in whole or in part as a public or private school having more than fifty pupils, or as a public or private hospital having more than twenty-five beds, or as a church. Outside of this provision, however, the whole burden of demand, and refusal, or acceptance of hundreds of petitions rests upon the shoulders of the Mayor and Board of Street Commissioners.

The arrangement of streets, and the adoption of zoning regulations are the two topics which have been most frequently touched upon here to-night. In all probability these two sub-

jects will afford a very fruitful field for the student of city planning in Boston for some time to come. Our park and playground system has been really developed, to a certain extent, with due regard to the requirements of the future; but we still have, among others, the problem of the development of our public buildings and their more extended use, and the development of our harbor, port and railroad facilities.

The total expenditures for Boston Harbor, made by the Federal Government, have been more than $12 000 000; while the Commonwealth of Massachusetts, in the 60-year period ending in 1919, expended more than $18 000 000 in its development and improvements; yet the statement has been recently made that, while port facilities at New York, Philadelphia and Baltimore were crowded, Boston was using only about 30 or 40 per cent. of what was available on its magnificent waterfront and harbor.

The City Planning Board has been studying these various problems during the eight years of its existence; and it has in that time made numerous recommendations, sporadic in a sense, but never one that has not been based upon a thorough, exhaustive and comprehensive survey of every possible factor entering in any way into the problem in hand. If we have had a single virtue in all these eight years, it has been in that one slogan, — comprehensive.

The dawn of the second century of Boston's municipal life, which we celebrated on the first day of May, 1922, means more than the turning of a single page in its history. It marks also the beginning of a new epoch in industrial life, the gradual readjustment of conditions from a war to a peace basis, and the settling down once more to the full enjoyment of our Constitutional birthright, — life, liberty, and the pursuit of happiness.

The City Planning Board felt that the time had also come to take a definite step looking toward future development in our municipal life, and accordingly recommended to His Honor the Mayor the preparation of a Comprehensive City Plan which should include all these problems which have been under discussion this evening, — streets, zoning, parks and playgrounds, public buildings, harbor, port and railroad facilities, not with

the idea that the adoption of such a plan would prove a panacea for all existent troubles, but with the conviction that it would lend emphasis and direction to future efforts.

The recommendation met with the approval of His Honor, plus his financial coöperation, and we now have at our disposal a sum sufficient to defray the expense of the first step in the preparation of a Comprehensive City Plan for the City of Boston. This first step will consist in the securing of expert consultants who will bring to the work a wider knowledge and a broader viewpoint, based upon actual experience, than has been available heretofore.

Probably there is not a single person here to-night who has not read with interest of the project recently launched for a Plan of New York and its Environs. The entire area within a radius of fifty miles is to be surveyed, portions of three states are involved, and a total of more than 300 political groups are found in the area concerned. It is an undertaking so vast, so comprehensive, as to challenge the wonder and admiration of us all.

While our plans may not be so ambitious as those of New York, they are actuated by the same desires, the same city planning principles will be applied to the solution of the different problems, and the results hoped for are identical. We have already been assured of the coöperation and assistance of several of the leading civic organizations, and I hope that a resolution is taking shape in the mind of every one of you here to-night to give to us the same whole-hearted sympathy and support which has been extended to the New York project, to the end that our hopes may be realized, and that future generations will find the prophecies of to-day accomplished, with New York working out her destiny as the "foremost city in all the world," — except Boston!

The last word I am going to leave with you to-night is not my own. It is the oft-repeated injunction of a man who is known to engineers as a pioneer in tall office building construction, one of the creators of the Columbian Exposition, architect of several large railway stations, the guiding spirit in that magnificent conception, the Chicago Plan, and at all times and above all, a City Planner, Daniel H. Burnham. His words, which have come down the years with all the force of prophetic wisdom,

contain not only a message but a mandate for engineers and for City planners alike, —

"Make no little plans; they have no magic to stir men's blood and probably themselves will never be realized. Make big plans; aim high in hope and work, remembering that a noble, logical diagram once recorded will never die, but long after we are gone will be a living thing, asserting itself with ever-growing insistency. Remember that our sons and grandsons are going to do things that would stagger us. Let your watchword be order and your beacon beauty."

Method Used in Presenting the Thoroughfare Problem in the Report of the Newton Planning Board.

Arthur A. Shurtleff.* — The importance of setting forth clearly and very briefly to the voters of a city the reasons for the selection of a certain group of streets for thoroughfares, cannot be overestimated. Unless the voters are thoroughly convinced that the lines selected are logical, there is little chance that officials will meet success in carrying these lines forward to execution. In the recent report prepared by the writer† for the Planning Board of Newton, Massachusetts, great pains were taken to present the thoroughfare problem in a way to catch and hold the attention of the "man in the street." The readers' attention was sought by the use of a series of thoroughfare maps and plans, some of which are reproduced below, and by a series of corresponding brief paragraphs printed in large type with attractive headings. As this material was arranged on large sheets, more than three times the size of the pages of this Journal, the effectiveness of this method of presentation can only be judged by reference to the report itself. It is hoped, however, that the following descriptions of the plans may lead those interested in the subject to refer to the report itself.

Evidently the "man in the street" is more incredulous regarding the thoroughfare system for an exceedingly irregular

* Landscape Architect, 89 State St., Boston, Mass.

† The preparation of these plans would have been impossible without the whole-hearted coöperation of all the members of the Planning Board and the Heads of Departments including the City Engineer, Edwin H. Rogers, Jr.

system of streets than concerning one which follows a rigid gridiron layout. For that reason, the first plan shown in the Newton Report illustrates the present street system and over it is written in large letters, "The Plan of Newton's present Street System looks confused." (Fig. 5.)

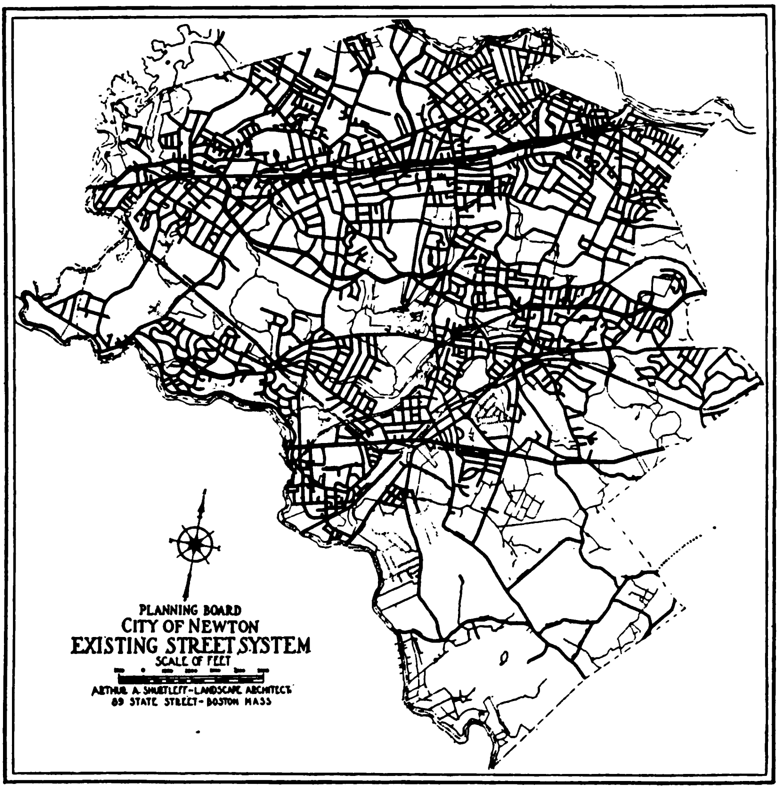

FIG. 5.

The reader is then reminded that the apparent confusion of the plan arises in part from the irregularity of the ground which makes long continuous straight streets impractical, and from the fact that Newton, like most other communities, grew by accretion without adherence to any rational plan. The suggestion was then made that an approach to a rational system of highways

might be discovered by the method of analysis which is illustrated in the four following diagrams. The first of these diagrams (Fig. 6) is evolved by combing the tangle of streets to reveal only those which lead continuously across the city from North to South. This diagram is accompanied with a large heading

FIG. 6.

reading, "Only Six Through Streets Now Cross the City North and South." The readers' attention is then called to the fact that this system of thoroughfares is inadequate as the streets lie nearly a mile apart and that intermediate through streets could be created if the fragments of intermediate streets were united.

The next cut (Fig. 7) shows the method of uniting these fragments to secure the thoroughfares described, and a careful statement is given of the distance separating these thoroughfares with a cross reference to the spacing of similar thoroughfares in well known so-called "Garden Cities" of the country.

FIG. 7.

An analysis of the existing through streets crossing the City from East to West is then shown in a diagram (Fig. 8). In this case, the combing operations reveal only East-West through streets and is described with a heading, " Only Seven Through Streets Now Cross Newton East and West."

Having held the readers' attention more or less successfully to this point, it is a simple step to indicate, by methods noted above, the feasibility of uniting street fragments to create many more through streets in this direction. This operation of piecing together is shown on the following diagram (Fig. 9)

FIG. 8.

which is entitled, "Twelve Additional East and West Through Streets can be Found."

Obviously the "man in the street" who is in a critical frame of mind, wishes to be assured still further of the wisdom of these thoroughfares by reference to a more detailed map giving the names of the fragments to be united, and recalling to his

mind the topography involved. These facts are set forth on a large plan nearly a yard square at the end of the report on which all these lines are combined.

FIG. 9.

The report also provides, for the use of those who wish to pursue the subject further, a schedule of street connections and street widths. Diagrams are also given showing the feasibility of accommodating modern traffic in streets of widely different capacity.

Thus far, the Newton report has met with unusual success as it has been widely read by the " man in the street."

DESMOND FITZGERALD.* — Mr. President, ladies and gentlemen: I have been exceedingly interested in this meeting to-night. We have had so many good papers and there have been so many excellent suggestions, I should like to say a few words in regard to the necessity of starting what we have been calling "City Planning" in towns before they become cities. Cities as a rule grow rapidly, but we have some very large towns and sometimes the towns prefer to keep their own forms of government as long as possible, as Brookline has done, rather than adopt those of a city. We have about 40 000 people in Brookline to-day.

As a rule people in the beginnings of things feel, I think, that it is wise to provide a civic center. There has been nothing said to-night about the civic center. I have been very much interested in the way Mr. Shurtleff has worked out his plan for streets and also what was said by Mr. Nye and by the lady who followed him; but another important point seems to have been overlooked, and that is the civic center.

There are several public buildings that every town has to have. It must provide a Town Hall, school houses and as a rule a library, a court house and police station,—and there are a number of buildings which have to be added as the town grows. It is important for us to impress upon the town in which we happen to live the great advantage of securing plenty of land at the very beginnings of settlement to provide for the growth of the town, and it is a splendid thing for us all to do for any town in which we may live, to see that it is provided with a very large and ample space for a civic center. Think of what an attractive public center we could have had in Brookline if it had reserved such a place twenty years ago. I gave up one vacation many years ago to study a comprehensive plan for this very idea and I tried to convince the town how necessary it was that Brookline at that time should provide itself with very large and ample ground for a civic center. Now shops and buildings have gone up on land which should have been reserved for the civic center.

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* Consulting Engineer, Brookline, Mass.

At the same time that ample land is set aside for a civic center the question of the character of the architecture should be studied. Think of what a deplorable condition arises when second, third and even fourth rate architectural designs are permitted. That is simply throwing away money. Such buildings cannot add to the attractiveness of a town. If some persons of great forethought and taste would only give the benefit of their advice to some of our towns I think that we should have a very different state of things. Then people would be attracted from all around to go and see a town with a beautiful civic center, — beautiful buildings, parks well laid out, — tasteful. Think of what a wonderful thing for a town to have. Some things I have seen on the other side have approached that. I have seen some in this country, but particularly on the other side. I remember some cities where, instead of locating magnificent museums on small spaces hardly big enough for the buildings, these cities have always provided ample spaces to give the buildings beautiful settings.

Almost the last thing we think of here is the setting of our public buildings. The result is that even a beautiful piece of architecture may be ruined by insufficient surroundings to give it dignity and distinction.

I didn't mean to speak as long as I have, but I hope you will all think this matter over, and I believe you can exercise an immense amount of influence as engineers, in this important direction.

E. H. ROGERS.* — The town of Brookline has been much interested in the subject of zoning, and I have here a copy of a report of the Selectmen in regard to a special town meeting which is to be held in Brookline, May 23, and as Mr. Varney, the Town Engineer, is not here to do so, I am going to read one or two paragraphs from the report of the Planning Board contained therein relating to zoning.

" *Zoning Defined.* — Zoning is the fair regulation of the use of private real estate by giving each piece of property just such protection and just such liberty as is most valuable and suitable

* City Engineer, Newton, Mass.

to it. Zoning acknowledges that there are different kinds of districts — such as residential, business, or industrial — and gives to each district such regulation of the use and construction of buildings as is appropriate.

"*Precedents for Zoning — Private Restrictions.* — Real estate men have for many years done their own 'zoning' in the form of private restrictions imposed by deed, as in a number of the best residential districts of Brookline. Practical realtors see the money value of proper regulation of the use of property: *the man who wants to invest in a home will not buy a lot where there is danger of a factory or a store building being located next to him.*

"*Disadvantages of Private Restrictions.* — Private restrictions are, however, unsatisfactory in many ways: they are applied to comparatively small and unrelated areas, they are liable to cause much litigation and any change before the date of their expiration is practically impossible.

* * * * * * * * * * * *

Store property is seldom protected by private restrictions, although it is obvious that stores may suffer from the proximity of such uses as garages and manufacturing in much the same manner as residential property. Zoning protects store districts."

The city of Newton also has been greatly interested in the question of zoning during the past two months. It has a very efficient Planning Board which recently made a recommendation to the city government in tentative form in regard to zoning with a proposed draft of an ordinance which was referred by the board of aldermen of twenty-one members to a special committee of the board consisting of seven members. This committee has gone in great detail into the zoning question and is preparing what it is believed will prove a suitable ordinance for the city, using as a basis at the start the ordinance submitted by the Planning Board which was suggested by Mr. John P. Fox of New York, who is probably as familiar with zoning ordinances as any one in the country. It was found by the aldermanic committee that the ordinance required a radical revision owing to the peculiar civic situation of Newton. As many of you know, Newton is divided into ten different semi-independent villages, — such as West Newton, Newtonville, Auburndale, etc., each one of these centers

having a local improvement society, a men's club, or some other group of citizens interested in the development of the village, and the zoning committee of the aldermen requested each village improvement society or other organization to hold meetings and hearings to get the ideas of the people as to zoning limits and restrictions. It also requested the Chamber of Commerce to have a committee appointed to review the findings of these local committees and add its advice. This has all been done, the various local committees having in general gone into the subject with great thoroughness, in one case canvassing practically every home in the district, to find out precisely what the people wanted. The results have been codified and embodied in the present ordinances so far as practicable.

As it is getting late I will review very briefly the manner in which this ordinance is worked out.

The city is divided into five districts, comprising four principal districts, — single residence, general residence, business and manufacturing, with a limited unrestricted district. The greater part of the city is classified in the single residential district, between 75 and 80 per cent. being so included according to the present draft of the ordinance. The balance of the area is largely in the general residential district which permits two-family and tenement or apartment houses, and the portion allotted to business and manufacturing enterprises, the two latter comprising 5 per cent. or less of the whole area of the city. In canvassing the inhabitants it was found that the majority of the people wanted their homes in the single family district, comparatively few desiring their property placed in the general residence or business districts. In some sections of the city it is quite apparent that people wish their property put in the single residence zone when really they might be better off in the business district, because if those owners of real estate located close to the growing business centers desire to dispose of their holdings they undoubtedly can do so to better advantage if they are able to sell it for future business purposes, although many feel if their property and that of their neighbors is restricted to single family use they will stave off business as long as they want to reside in the district.

There is one locality in Newton in which some of the few mills in the city are located, being one of the older parts of the city, and in that district the people, at the meetings that were held, indicated they wished to have practically the whole of that part of the city put in the manufacturing district, so that the mills and factories would be given a chance to expand and the property owners might be able to eventually sell their property to the mill owners for manufacturing purposes or the erection of model homes at a possible enhanced valuation.

Another important item of the proposed Newton ordinance is the setback lines, as they are called. There is in the General Laws a provision for establishing building lines at certain distances back from street lines. This ordinance provides setback lines under a different law and which is extremely advantageous as damage suits are unlikely to occur. In the single residential zones 25 feet, and in the general residential 15 feet, is the setback adopted, — substantially the same as has been favored in Brookline. In the business and manufacturing districts there are no setback lines.

It is generally realized that a zoning law should be both permanent and elastic. It should ensure permanency as far as possible, so as to assure people who buy property of the permanency of the neighborhood. On the other hand it should be sufficiently elastic so that the character of a district or zone can be changed as necessity demands. It is absolutely imperative to allow more room for stores and for business as a city grows. The General Laws of the commonwealth provide that changes can be made in a zone only by a three-quarters vote of the board of aldermen or other governing board, if there is any objection from persons interested, and in no event by less than a two-thirds vote; so property owners in general are pretty well safeguarded from unwarranted changes.

In line with Mr. Nye's discussion I see a member here who has had much experience in Board of Survey work. I refer to Mr. F. O. Whitney of the Boston Street Laying Out Department who may be willing to add something of interest.

FRANK O. WHITNEY.* — The hour is rather late and this is not a new subject. Besides it has been quite thoroughly covered, and the difficulties brought out very clearly by Mr. Nye. I do not take quite so pessimistic a view of the working out of the Board of Survey law as he seems to. I think in the City of Boston it has worked out as well as could be expected. The Board of Survey was created just thirty-one years ago and you all know how difficult it is to look forward fifty years or more to what the needs may be, and to provide street systems that will be suitable for the future time, so that many changes have been necessary. The law, as Mr. Nye says, has no penalty except deprivation of public improvements where the law is violated; and I think that the experience of Boston has been that that penalty is practically sufficient, because people who are developing land need the public improvements. Buildings are practically useless unless they can have public improvements and unless they do have them the Board of Health will undoubtedly become active, so on the whole the Board of Survey law has worked very well in Boston.

There have been some conspicuous violations. I have one in mind of a large area where about 60 acres were developed by a real estate owner who advertised it as a camp and laid out streets where we had a system of suitable streets 40 ft. wide, as a rule, and had decided the lines and grades; and who developed a plan of streets 15 ft. wide and house lots 20 ft. wide, and sold to unsuspecting people who built more or less permanent buildings and found no water supply or sewerage conveniences. The Board of Health, the Public Works Department, the Street Commissioners and the Law Department have been puzzled to know how to deal with this territory. We cannot give them those improvements because they have violated the law, and they are in very bad straits. I have a list of those streets and when applications for permits to build come to me, if I see one of those names of streets, I recommend that the request be denied or the petitioner be informed of the real condition.

The Board of Health is seriously puzzled about it. We cannot widen the streets. If we widen them the building lots

* Chief Engineer, Street Laying Out Department, Boston, Mass.

will become too small to be serviceable. The water supply consisted of pipes laid on the surface of the ground and a fountain where one could draw water in a bucket, and these froze up the first season.

This is an extreme case. It is one of a very few. On the whole the law has worked very well. I think the Ex-Mayor will bear me out that it was a good thing to have the Board of Survey Law.

There is just one other matter I would call attention to as a matter of interest, — and that is that the City of Boston has been considering a zoning system. This subject was brought to the attention of the Street Commissioners by Mayor Peters about a year and a half ago and the New York ordinance and maps were very carefully studied, and first a plan was drawn dividing the whole city into zones, — the residential, restricted, unrestricted, business and mercantile. The whole city was covered and an ordinance was written, based practically upon the New York ordinance, though not so detailed. New York goes into the building problem very largely.

We have good building laws here in Boston and it is not necessary to go into building construction in our zoning plan. The Mayor presented it to the Council for action. They have not yet reported on it. It has also been before the Planning Board for criticism and suggestion.

MORRIS KNOWLES.* — Mr. President and fellow members of the Boston Society of Civil Engineers and ladies, — I came in late to-night at the conclusion of another meeting and have not heard all of the papers and did not expect to be called upon. I am a native of these parts, although now a resident of the Middle States for some time, but still always interested in what is going on here at the Hub.

The discussion of city planning at a meeting of engineers is indeed appropriate, in view of the fact that the engineer has been in the past the original city planner. If he has given good engineering service, then he must have planned for all municipal developments and has looked ahead in laying out water works systems, sewers, highways, lighting and transportation.

* Consulting Engineer, Pittsburgh, Pa.

This subject is also appropriate to be discussed here in the City of Boston. I was particularly glad to hear the Mayor speak of the Metropolitan District, as I have always regarded the early work in Boston, the development of the Metropolitan Water-works and Sewerage Districts, as among the pioneer endeavors in this country. It would be too bad, indeed, if petty jealousies of the various communities making up this district should prevent their full coöperation in the future and delay working together for the benefit of all of them.

However, the human element is one of the greatest difficulties in the development of town planning and particularly in the creation of metropolitan districts. General Chittenden once made a remark in connection with the Miami Conservancy District, that the time taken and the money spent to educate the people in the various sections of the district was as much as the time and money spent on actual engineering on the project. The delays in the organization of the Miami District were due to human elements involved and not to physical and financial problems.

One of the most popular and most active phases of the city plan in this country to-day is that of zoning; the direct effect of lack of zoning on depreciation of real estate values being so clearly apparent, is no doubt the cause of the predominance of this phase of city planning to-day. The introduction of garages in a residential district, the erection of obnoxious buildings, the maintenance of nuisances and the introduction of objectionable industries are things which directly affect the pocketbooks and attract the public attention. These things particularly have probably given the impetus to the great demand for city zoning.

In this connection, I may refer to the fact that zoning in itself cannot be solved without a consideration of its relation to the other elements of city planning and to a full knowledge of existing conditions and how they are likely to change.

I wish also to call attention to the work which is being done by Secretary Hoover of the United States Department of Commerce along these lines. He is trying to do for the urban communities of the country some of the things in this way that the Department of Agriculture has been doing along similar lines

for the farming interests of the country. One of the activities arises out of the appointment of a committee to study a Standard Building Code, and the other is due to the work of a similar committee to study Zoning.

Among the first things to attract the attention of the Committee on Zoning were the cases where regulations are being advocated and studies progressing without any adequate investigation and information on the correlated subjects of city planning. It was thought in these communities that zoning ordinances could be successfully worked out without a consideration of the city plan and its development. However, this is not the case.

With regard to the zoning work, there has already been issued a Zoning Primer, which is being given publicity by the National Association of Real Estate Boards. Portions are now being printed in the real estate section of the Sunday editions of the various newspapers. It will probably take about a month or so to complete its appearance in that form, and then it will be released for general publication and it can be obtained then in pamphlet form by everybody. The Zoning Committee now has under consideration a Standard Enabling Act which has been drafted. When this has been completed, the Committee will then consider a typical ordinance with annotations and discussions.

As previously stated, the big end of this work is the development of public opinion. Colonel Roosevelt once said, "This country will not long be a good place for any of us to live in unless it soon becomes a good place for all of us to live in." City planning and zoning will be the result of just such public thinking and discussion as this here to-night, for city planning is not a one-man-job, but needs the full coöperation of the community and of all the men and women making it up. I was much interested in attending a meeting in New York the other night, held under the auspices of the Russell Sage Foundation, to note the interesting cross-section of the people of New York. There were engineers, architects, artists, lawyers, corporation leaders, bankers, people of means, social workers and many

others, — all united in one cause, namely, the development of the surroundings of New York City, rather than the city itself.

At the annual meeting of the Chamber of Commerce of the United States held in Washington last week, much interest was shown in the work of the Civic Development Department of the National Chamber. Nothing emphasized the need of immediate town planning so much as a statement by Col. Leonard P. Ayres, Vice-President of the Cleveland Trust Company, in discussing the building industry. He showed that in fifty cities in this country they were on the average two and one half years behind in the erection of buildings, and that the immediate future must carry an overloading of approximately 20 per cent. a year to catch up with the present lack. If such a building program be carried out in this country, it shows the pressing importance of adequate planning, in order that wise locations and arrangements shall be determined for our future growth.

The great point which Colonel Ayres made was that unless there is adequate planning now a great deal of this work will be carried out in a shoddy fashion, poorly arranged and cheaply constructed — built too rapidly but not wisely planned. Wise planning is the great need of the country to-day.

BERTRAM BREWER.* — Mr. Nye's paper sets forth the negative and discouraging aspects of the problem of securing good street planning, but no one could look upon the illustrations which he showed of what has been accomplished in the city of New Bedford without realizing that it has been Mr. Nye's good fortune to accomplish very much notwithstanding the handicaps he so admirably describes.

The writer was instrumental in securing the passage of certain Board of Survey laws and had a dozen years' experience in working under them. This experience and the maturer opinions which have come from a retrospect after a period in the thick of the battle have led him to believe that too much law is as undesirable as too little, and that we certainly have enough to accomplish very much. Those who have succeeded in positions of authority know that there must be a give and take spirit in municipal affairs, and that in the long run persuasion and edu-

* With the State Department of Health, State House, Boston, Mass.

cation have a decided advantage over compulsion. Furthermore, all boards of survey are not as well advised as the New Bedford board, and perhaps are not fitted to undertake the larger responsibilities which go with larger powers.

In the matter of control of new streets, the writer believes that we have all the authority necessary because an appeal by the municipal authorities can be made to the more selfish instincts of mankind. It can always be said that it is for the interest of the home buyer to purchase a lot on a street which can be accurately located at any time, having a grade which is recorded and is acceptable to the municipality. It doesn't take much persuasion or reasonable advertising to convince the average man of these advantages. Moreover, the majority of real estate operators, when they find that they have a competent official to deal with, are also glad to take advantage of Board of Survey laws. The competency of the officials, however, is of prime importance and does not always have the weight that it deserves.

There may be some question about authority where existing streets should be widened or relocated and new streets laid out in a built up district. Most such improvements are expensive and are easily blocked and it is usually a hard struggle to accomplish anything worth while. It is very easy, though, when one is in the fight and is perfectly satisfied that what he wishes to accomplish is for the best interests of the community, to wish that he could compel the action which he knows to be desirable. It is always well to remember, however, that it doesn't pay to go too far beyond the average public sentiment.

The best weapons are always at hand and they are easy to command. The newspapers are always ready to advertise and discuss or to publish anything worth while on a municipal improvement. Sometimes the politicians will use a good plan as a campaign slogan, and, better still, there is always a group of intelligent persons in any community who will be glad to learn the details of any well thought out plan and will pass it on with a recommendation to their neighbors.

A special writer for one of the Boston papers says that he judges the value of an item which may go into his story by its

value for repetition. That is, he considers whether it is the sort of thing which one would read and then repeat to his neighbor next day. There is a whole world of publicity open to the planner which has hardly been touched, expecially of the sort which appeals to the ordinary man.

Innumerable ways for education and for promoting a good and desirable improvement will occur to everyone, but the writer cannot close this discussion without reference to one other which occurred to him during Mr. Shurtleff's interesting exposition of several planning projects in which he has been interested. Massachusetts is more fortunate than any other State in America in its expert city planners, and there are at the command of its cities and towns men whose reputation is country wide. The advice and backing of a specialist are always available to that municipality which is awake to the larger opportunities for improvement which can come only with proper planning.

R. A. HALE.* — I should like to add a word of tribute to Mr. Charles H. Storrow, grandfather of James A. Storrow of Boston, in laying out the City of Lawrence, — the water power development, the mills and canals and the principal features. Main Street is 80 ft. in width, and the smaller streets 60 ft. In the center of the city is a large common park which is practically the civic center of Lawrence, as there are grouped about it eight churches, a high school, masonic building, City Hall, and various other structures which make it the main center. Shade trees were planted and the residential portions were planned in certain parts — practically a zoning system, and all done in a very systematic way. It has not worked out quite as expected, but no buildings over 10 ft. in height have been put up unless they are of stone, brick or durable material, and in many parts of the city there are restrictions in regard to setting back. The greater part of the deeds make a restriction with regard to the sale of intoxicating liquors, although such a deed seemed a little odd when it provided that the Methodist Church should not sell intoxicating liquors.

* Engineer, The Essex Co., Lawrence, Mass.

The matter is now in the hands of a Planning Board which, however, has not been very active. The zoning system has really got to be taken up as foreign population has invaded the residential district in such a way as to make it very uncomfortable for the old residents and it will be interesting to see what can be done about it.

MEMOIRS OF DECEASED MEMBERS.

CHARLES EDWIN HABERSTROH.*

CHARLES E. HABERSTROH was born in Boston, February 13, 1849, the son of John J. and Martha A. (Mason) Haberstroh. He died at his home in Framingham, September 24, 1921.

He married, in 1877, Helen A. Chase. His family at the time of his death consisted of his wife, a son, E. Roscoe Haberstroh, and three married daughters, Mrs. Charles N. Hargraves, Mrs. George Sullivan and Mrs. Herbert E. Damon. His wife survived him but a few months.

Mr. Haberstroh was an engineer of great activity and energy and was among those who fulfilled important positions in the employ of the City of Boston and later of the Commonwealth of Massachusetts in connection with the Sudbury System of water works, which on January 1, 1898, was transferred from the City of Boston to the Metropolitan Water Board.

His earlier education was obtained in the public schools of Boston, graduating from the English High School in 1870. He entered the Massachusetts Institute of Technology in 1871 and remained there three years, when he left to accept a position on the engineering force of the Boston Water Works at what, at that time, was known as South Framingham, in the newly established office of the Sudbury Reservoirs and Aqueduct.

The Sudbury System, planned by the late Joseph P. Davis, past-president of our society, and which was large and comprehensive in its inception for those early days — being the second stage in the provision for the Boston Water Supply — was then barely outlined and construction was just beginning. Mr. Haberstroh thus began his engineering career under the influence, tutelage, and guidance of such men and accomplished engineers as Joseph P. Davis, Alphonse Fteley, Frederic P. Stearns and Desmond FitzGerald.

* Memoir prepared by Frank S. Hart and Frederic J. Winslow.

He remained to see this work developed and completed, practically as originally planned; and he grew up an important factor in its consummation, as he was in the same office, with successive promotions, until his seventieth anniversary, being for many years the Assistant Superintendent of the Department.

He lived to see the water supply of the Sudbury river watershed become too small in quantity for the population depending upon it for an adequate source of supply, and to take its place as a part of a much larger system. He met the changing conditions of the situation by keeping in close touch with its growth.

Being a man of push and activity, these characteristics found their vent in giving service to his fellowmen in various public ways, always without compensation. He served for nine years as a member of the Framingham School Committee, during which time the High School building on Union Avenue was erected, at that time the largest and most prominent municipal public building belonging to the town.

He was for several years, and at the time of his death, a vice-president of the Farmers and Mechanics Savings Bank of Framingham, one of the largest and most important institutions of its kind in the vicinity.

He joined the Boston Society of Civil Engineers on September 16, 1885, and later the New England Water Works Association.

He was a member of the Alpha Lodge Free and Accepted Masons of Framingham, the Framingham Country Club, and at one time was president of the old Framingham Club.

Mr. Haberstroh, in line with the maxim of Francis Bacon, "Every man is a debtor to his profession," contributed a valuable addition to engineering literature in an article on hydraulic experiments which appeared in the *Journal of Engineering Societies* for January, 1890, being read before the Society at the meeting in May, 1889. The experiments and articles were inspired by our honored fellow member Mr. Desmond FitzGerald, the Resident Engineer and Superintendent of the Western Division of the Boston Water Works and at that time the President of our Society.

They were of the class which has given New England Civil Engineers a reputation for comprehensiveness, exhaustiveness

and reliability and were especially appropriate in supplying information relating to data desirable concerning the flows through the standard pattern of gates in general use on the Boston and other water works reservoirs and at the overfalls at the dams.

After many years, during which he filled under the City of Boston and the Metropolitan Water Board, the position of Assistant Superintendent, in 1907 he was appointed Superintendent of the Sudbury Department, and while the work of this position was one largely of maintenance, it was the quality and scope of engineering work demanded of him, and others in like positions, which led the Metropolitan Water and Sewerage Board to make the following statement in its report for 1917:

"It may be claimed with entire justice that the ability adequately to main'ain a complicated system of water-supply requires qualifications not inferior to those of the men employed in the original construction, however they may differ in character."

In line with this very appropriate and deserved sentiment, the same Board on February 13, 1919, on the occasion of the retirement of our fellow member, passed the following highly commendatory resolution:

"In the retirement of Charles E. Haberstroh, Superintendent of the Sudbury Department, which occurred February 13, 1919, the Board feels that the Commonwealth has lost a capable and faithful servant who has rendered useful and important service in the construction and maintenance of the Metropolitan Water Works. Mr. Haberstroh was connected with the water department of the City of Boston for many years prior to the acquisition of the works by the Commonwealth and had a comprehensive and practical knowledge of the Sudbury Department of which he was appointed Assistant Superintendent by the Board at the time of the taking of the Boston Water Works in 1898.

"In February 1907, he was promoted to the Superintendency because of his knowledge of the Sudbury Department and held that position until his retirement.

"His employment of more than twenty-one years has been characterized by faithful devotion to the work with which he was entrusted and untiring zeal in the discharge of the many and arduous duties devolving upon him."

The Committee thinks it fitting to also place upon record the following tribute by Mr. Desmond FitzGerald, who more than any other engineer, had long and intimate dealings with our deceased brother:

" Mr. Haberstroh's long and faithful service for the Boston Water Works has ended, but the memory of his devotion to his work will abide for a long time with those who were familiar with his career.

" During all the years that I was associated with the department, I trusted him implicity, and I cannot recall a single instance where that trust was violated. The nature of his duties was such as to call for undivided attention to many efforts in different directions and covering a large area of operations. The regulation of the flow on the aqueducts, the attention to rainfall and other records, the superintendence of extensive areas of territory contributory to the supply of water to Boston, called for unfailing efforts and good judgment in dealing with towns and individuals upon the watershed."

WILLIAM NELSON.*

WILLIAM NELSON was born in Laconia, N. H., April 20, 1871, and after a lingering illness passed away there at his home on March 13, 1922.

He was educated in the Laconia public schools and was graduated from the High School in 1887. From that time until 1890 he served his apprenticeship in the machinist trade and also studied civil engineering; then was employed for several years by the Concord and Montreal Railroad in Concord, N. H., in the engineering, maintenance of way, department.

From 1892 to 1900, he served as City Engineer, Superintendent of Sewers and Street Commissioner in his native city, where his faithful, conscientious service will long be remembered. He organized the Public Works Department and laid the foundation for its future policy on a sound basis, and he had charge of the construction of the sanitary sewerage system which was begun during his term of office.

* Memoir prepared by Chas. A. French and C. Frank Allen.

Following his resignation from office in Laconia, he installed machinery and stone crushing plants through New England, and was with the Fairbanks Co., in Bangor, Me., as manager of a large mill supply and wholesale house. Later he was sent to Binghamton, N. Y. by this firm to erect, equip, organize, and superintend a $750 000 plant for the manufacture of brass and iron body valves. By order of his physician he was compelled to give up this work in March 1911.

He then became Vice-President of the Osgood Scale Co., later becoming President. At this time he was elected Secretary of the Binghamton Chamber of Commerce, and perfected the consolidation of this organization with the Mercantile Press Club, with a combined membership of 600.

During the war he was connected with American Red Cross as Assistant Director of the Atlantic Division, doing intensive campaigning and organizing.

In 1918, he became connected with the Walworth Manufacturing Co., as Consulting Engineer for the firm.

Mr. Nelson became a member of the Boston Society of Civil Engineers in March 1897, and had been an Associate Member of the American Society of Civil Engineers since March 1900. He was a member of the Congregational Church and a Past Master of Mt. Lebanon Lodge, A. F. & A. M. of Laconia.

He married, in 1892, Mina L. Flint, who survives him, together with two sons and a daughter.

He was intensely loyal to his family and his friends, and his death is a great loss to his native city.

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

REHABILITATION OF STREET RAILWAY TRACKS.

By FRANK B. WALKER*, MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

(Presented September 20, 1922.)

IT is obvious that if tracks are properly maintained, rehabilitation will not be necessary.

The tracks of the old Bay State system prior to its reörganization June, 1919, had not been properly maintained and it became necessary to begin a very heavy program of rehabilitation when the Public Trustees took charge of the property of what then became the Eastern Massachusetts Street Railway Company.

I shall briefly point out some of the conditions under which this work was carried out and explain some of the methods employed, showing a few slides as we go along.

Our system covers the eastern section of Massachusetts, from the Merrimac Valley on the north to Fall River to the south, but with very little mileage in Boston proper. We operate about 700 miles, of which half are unpaved country lines and half are paved city lines. Our country lines are constructed for the most part alongside of town roads and state highways and when the work started three years ago, they were in a deplorable condition, to say the least. They were low and badly drained, the ties were bad, rails out of line, surface and gage, and the joints were low, battered and pounding. We have now com-

* Chief Engineer, Eastern Massachusetts Street Railway Co., 1 Beacon St., Boston, Mass.

pleted the overhauling or reconstruction of about 200 miles, which, together with about 50 miles which were in good condition, gives us 250 miles of very good country track and leaves less than 100 miles to fix up in 1923 when we plan to complete our program.

At the start it was thought necessary to relay the major portion of the mileage of country track with new rail, but with the methods gradually developed we have been able to save many miles of light rail formerly thought worn out. This was done by various methods, such as surface benders, joint welding, surface welding and grinding, all of which I refer to later.

Our city paved tracks were very bad, although not so bad as the country tracks, but bad enough. In cities, street railway engineers are faced with very difficult and expensive problems due to the requirements of street pavements. Country lines are laid with Tee rails, 48 lb. to 75 lb. per yard and paved tracks 90 lb. to 140 lb., 7 in. to 9 in. high, buried in macadam, concrete or granite block pavements. Maintenance and renewals are expensive and reconstruction much more so; yet we have entirely reconstructed 40 miles and have made very substantial repairs to many more miles as well as to completely renew 700 pieces of special work, such as curves, frogs, switches and mates. On both classes of tracks, we have installed very nearly 400 000 ties, — overhauled, rebuilt or repaired about 300 miles, — ground the surface of 75 000 joints and ground the corrugations from the tops of about 120 000 lin. ft. of girder rails in paved streets. We are planning on completing the rehabilitation of the system in 1923, — at least to the point where normal maintenance only is necessary.

Someone has said that the street railways of New England constitute its drainage system. Some of our old tracks seemed to prove this. They were usually well below the highway, completely backfilled, and had no good system of drains. During spring thaws and rainy days many miles were completely submerged. Some of our city tracks were as bad. One winter we lost, by burned out motors alone, the sum of $600 000.

Our method of improving this situation was to raise the tracks out of the mud, put in 6 in. to 18 in. of good gravel ballast,

clean off the backfill above the ties by making full open section where we could, or half open in other places, and to dig deep side ditches and off-take ditches. (Figs. 1 and 2.) In this work we were

FIG. 1. — HALF-OPEN SECTION.

Track raised to level of highway with good gravel ballast, backfill cleaned off, deep side ditches and off-take ditches provided.

FIG. 2. — EXAMPLE OF OPEN SECTION TRACKS ON BOSTON ELEVATED RAILWAY.

assisted very materially by the coöperation of city, town and state highway engineers when they realized our purpose and saw the results, and the results have been remarkable. The drainage of

city tracks was accomplished largely by the raising of tracks and the placing of more track catch basins.

The matter of better ties was given considerable thought and we have adopted a good tie for street railway, using on country lines a chestnut tie untreated, 6 in. x 8 in. x 8 ft., although some of these have a face of 6 in. when hewed ties are used. Our paved tracks are retied with 6 in. x 8 in. x 8 ft. yellow pine treated with 10 lb. of creosote oil. Chestnut ties in open tracks have a life of 12 to 15 years and in paved track 18 to 22 years. With treated pine ties we hope to have a life of 25 to 30 years.

FIG. 3. — REHABILITATED TRACK IN FALL RIVER.

7 in. Tee Rail, 91 lb. per yard — tie plates — 6 in. x 8 ft. creosoted pine ties on two foot centres — broken stone ballast — concrete base — stone block paving.

We are ballasting country tracks with at least 6 in. of good, clean gravel and our city paved tracks with at least 6 in. of broken stone, rolling the sub-grade and also rolling the stone ballast before laying the track. Our best country lines are laid with 75 lb. A.S.C.E. Tee rail with welded joints and our paved tracks with 7 in. Tee, 91 lb., or 9 in. girder, 104 lb., — the 7 in. Tee being our standard and used wherever the depth of paving will permit,—tie plates being used on all paved tracks. (Fig. 3.)

All tracks, both country and city, overhauled or rebuilt, have all joints welded and ground, and to me, the process of proper treatment of joints is the most interesting. In fact, your Secretary cautioned me not to spend all my time on welding. We have used several very satisfactory methods of welding joints: the Lorain bar, (Fig. 4 and 5) which is spot welded by an electric current; the Thermit, which is a chemical reaction designed to fuse the rail ends together; and the so-called seam weld by using either the carbon arc or the metallic arc to place a metal bead along the top and bottom of plates at the rail ends.

FIG. 4. — NORTH AVE. WAKEFIELD-READING LINE.

Left hand track completed, right hand track being welded.

All of these methods are good if properly applied. None of them are perfect, but we have for the past two seasons employed the metallic electrode arc method most successfully, and for the moment, believe it to be the best for our work. So far we have never found a failure. True, we have had plates break, also rails break, but these types of breaks do not total 2% of the total joints welded and are probably due to temperature stresses or defective rails or plates Expansion joints are put in about 750 ft. apart on open tracks, but no expansion joints are needed or ever put in on paved track, as it can be readily shown that if

rail is held in line by pavement, temperature changes produce stresses which are well below the elastic limit of the rail.

In repairing a joint on old rail, we first repair or renew the

FIG. 5. — NORTH AVE. WAKEFIELD–READING LINE.
Left hand track before rehabilitation, right hand track during rehabilitation.

FIG. 6. — VERTICAL RAIL BENDER.

ties, then clean the plates of scale and rust, replace them with bolts or a clamp, bend the rail slightly above the proper surface with a sturdy rail bender of our own design (Fig. 6), retamp the

ties, weld on the plates, surface weld the cup if there is any in the rail and then grind the surface to a perfectly level plane with either a rotary grinder or a reciprocating grinder. The result is a solid, smooth riding joint and one which should require very little maintenance.

New rail is welded the same way, except no vertical bender or surface welding is needed. All joints of new rail are ground to remove all irregularities at the joint due to mill rolling tolerances. We are doing very little bonding at rail joints as the welding serves to carry the negative current return satisfactorily, — the electrical resistance being no more and usually less than the equivalent amount of rail. A recent bond test of 450 metallic arc welded joints a year old indicated 449 of them perfect electrically and one a trifle high. This is considered more nearly perfect than we had ever hoped for.

Our seam welders (not sewing machines) are of the dynamotor or motor generator type, of a reversed polarity, using 20 volts and about 150 amperes. Our surface welders are of the resistance type of much less electrical efficiency due to the high resistance. They are direct polarity. Of grinding machines, we use two general types: the rotary type, using a 14 in. emery driven by a 5 h.p. motor, of which we operate about 30; also the reciprocating type which is essentially 4 carborundum bricks moved back and forth over the rail by a 5 h.p. motor through a crank and eccentric action. We have 10 of these and they are used for grinding corrugations from the heads of rails and on surfaces of joints of new rail. The rotary machines will grind 15 to 30 joints per day and the reciprocating machine 200 to 400 ft. of corrugated rail, — all depending on traffic conditions and amount and depth of corrugation, as well as hardness of the rail.

I have great hopes that metallic arc welding will be used more in structural work. I have already used it in some bridge repairs as, for instance, repairing a damaged I-bar on the Merrimac River, Lowell. We also assisted the Bridges and Ferries Division in repairing a broken 6 in. turning shaft of the North Chelsea Draw by Thermit welding it. This shaft broke again the other day, but not through the weld.

Our tracks are still far from 100 per cent. condition, but we hope to see nearly 70 per cent. condition in 1923. Better work must be done on street railway tracks than ever before. It is not a solution of large engineering problems or the spending of large sums, but it does mean close attention to details and building up of proper morale of the men and a further training of men in the best way of doing work. We are so confident that the best work can be done only by men properly trained, that we conducted a Winter Track School during last December, January and February, in which we attempted to train 125 of our engineers, roadmasters and foremen. Illustrated lectures each morning of the week were followed each afternoon by shop work and the results obtained this year by instructing these men amply repaid our efforts in conducting the school.

It will be noticed that in my discussion of the rehabilitation of tracks, I have made no particular reference to the effect on the cars which operate on our tracks. There has been a marked change in the weight and character of rolling stock in use on street railways during the past few years.

On our own lines, when the old horse cars were remodeled for electric traction the companies were using cars with a weight of approximately 7 tons. Many of these were the old horse cars with motors on them, but as a general rule most of the early equipment was very light. First they had 4 wheels, and later, as the weight and length of cars increased, double cars of 8 wheels were used. Weight gradually increased from the early nineties to about 1918 when they were operating cars of from 22 to 25 tons.

The equipment on our property was getting in very bad shape, not only on account of lack of maintenance of the equipment, but due to the constant jarring and pounding which the cars received as they passed over bad joints. During the last few years, street railway companies, particularly our own, have started to use a very much lighter equipment, and the so-called Birney safety car, of which we have several hundred, weighs 8 tons. These have 4 wheels spaced 8 ft. between axles.

Recently, a few cars with 8 wheels have been purchased which weigh 13 tons.

We are already noticing considerably decreased maintenance costs in our track due to the fact that more light weight cars are being operated. We are also experiencing a very decided decreased maintenance cost in the rolling stock department, amounting to at least $100 per car per year, due to the work of rehabilitation which we have carried out in the past three years on our track system, so that we are not only receiving a very substantial benefit in reduced maintenance cost of track, but we are also receiving a large benefit from reduced maintenance cost of equipment and other benefits due to increased comfort of car riders and people who live along the lines.

DISCUSSION.

DUGALD C. JACKSON.* The moving pictures we have just seen show something that ought to be interesting to us, and that is the traffic that goes on while the construction is proceeding. One of the cities that has recently had to repair a track in the city proper, put into effect a method of modern mechanical construction, and the citizens saw how the work went along and actually requested that in order to facilitate the work and get the interference with business out of the way, that each block as it was to be reconstructed, should be closed to traffic, except on the sidewalks, so that the whole thing could be done as rapidly as possible in that block, giving the street railway construction gang the whole width of the roadway to carry on its work. In that way they were actually able to clean up a block in about ten days, — to tear up the track and put down the new track and pave; and the merchants considered they had saved much in disturbance of their business by having vehicular traffic shut off and having the street open in a briefer time than would otherwise have been possible.

That is an aspect municipal engineers may well consider. Of course there is not so much difficulty with traffic in the country. The Elevated Railroad must have that worry very definitely.

MR. WALKER. The question is asked as to how the flangeway is kept in place with the common Tee rail? There

* Professor of Electrical Engineering, Mass. Inst. of Tech., Cambridge, Mass.

are two general methods employed. One method is to cut off the corners of the blocks for the flangeway and the other is to lay the stone block against the head of the rail, with an inch wooded strip between the rail and the block, which forms the flangeway. The base of the flangeway is filled with cement grout.

A good example of this is the State highway built for the Town of Andover from the Academy to Elm Square, a little less than a mile. A Tee rail was used, and stone paving on a concrete base. The flangeway was made by putting in a wooden strip.

In Fall River we have employed both methods, one to cut the corners of the blocks off and the other to put the blocks up against a wooden strip. With macadam it is rolled up at the head of the rail and cut off afterward.

With reference to the relative quietness of the Tee rail and the girder rail we find that the Tee rail is the more quiet. Where the rail is uniform section, it doesn't seem to set up the vibration that the eccentric section of the girder rail does. It does not corrugate so rapidly. I think I am safe in saying that this corrugation has something to do with electric traction. We do not get it on steam tracks. It may be due to unequal slippage of the wheels. Every engineer I ever met has difficulty in assigning a cause to it. We do get them, however, and the only way is to take out the rail or grind it down. The girder rail is very noisy.

Prof. Jackson suggests that corrugations do occur in steam railroad track, and that on the Pennsylvania Railroad track he has noticed them near the stations where the trains start. These looked very much like the electric railway corrugations.

The only corrugations I have ever seen in steam railroad track have usually been around the water station or coal station where there was actual slippage and burning of the rail, and that is entirely different from the corrugations in an electric rail.

You might see them on approaching sides of the station where they were operating under steam and put on the brakes. We get them on down-hill tracks and not on the opposite up-hill tracks. This may be due to the motors being under power

and the motorman having the brakes on and possibly the motors not working together and getting unequal slippage. We get them both on curves and on straight track. We sometimes get one rail corrugated on a straight track, and not the other. It is my belief that it is due primarily to unequal action of the motors on the car.

Questions are asked as to the cost of electric tamping machines and as to the relative cost of rehabilitation and new tracks. The cost of a four tamper machine is about $1 600. In addition to the tampers a converter is required which is a large part of the cost. An air tamper would probably cost $2 400 to $2 500.

Very roughly the cost of a city track, exclusive of paving, is in the neighborhood of $5.50 a foot. Rehabilitation of a paved track is not carried out in the same manner as the rehabilitation of a track in the country. About all you can do in the city is to put in a tie here and there, repair joints and weld them. It is costing our company nearly $20 to repair a joint in a paved track, with concrete base and granite block pavement. That includes digging out the blocks, digging out the concrete, preparing the ties, welding the joint, surface welding it and grinding it. There are two joints in a rail length, which would make it $40 a rail length. The rails are 60 ft. long, so that amounts to about 67 cents a foot of track, which is not large compared with new track. If the life of the track is increased one year we prefer this method to tearing it up. On a country line new track costs $3.50 to $4 a foot. Our rehabilitation work including welding, overhauling, ballasting, renewing a few of the ties, lining and surfacing, costs probably at least $2 a foot of track. In a great many cases where the rails were supposed to be completely worn out we have been able by the development of the methods which you have seen to re-use the old rails to a very large extent, and you will find that old rails were used on 100 to 150 miles of the track which we have rehabilitated.

Sometimes we can reverse the rail but usually it is not worn enough on the gage side to swap it, except on curves. That practice is customary both on steam and electric lines and is one advantage the Tee rail has over the girder.

Prof. Jackson asks "if steel cost one-third less than it does would you do as much rehabilitating?"

We would do the work if the rails were not costing us anything, because it costs a lot of money to take out the old rails. I wouldn't want to be held to that absolutely, but the rails must be in very bad shape before they would be taken out.

When I was in Harrisburg I saw at the shops of one of the steel companies rails which the Pennsylvania Railroad had sent in to have 18 inches cut off the ends on account of battering, after which they will be used again. At the joints the rail takes a compound curve, a sharp dip at the end, which you cannot take out with rail benders. It also takes a long bend. This long bend we have taken out with our vertical benders. This occurs in the 9-inch rail and the light Tee rails. I am inclined to think if they cut off 12 or 18 in. of the rails at the end they should afterward use rail-benders to take out the long bend. So far as I know steam railroad engineers have not yet used these vertical rail benders.

A great many street railways are built with a concrete base. The Detroit Municipal Railway built about 80 miles of track using 70-lb. rail on light steel ties, set in concrete. Some engineers believe that is the solution. I am not prepared to say. I believe the Boston Elevated has used it. In Lowell there is a double track, one on steel ties, one on wooden ties. An examination of these tracks recently indicated the rails were working well on both. The rails wear out before the ties. Even on the Eastern Massachuetts we anticipate the rails will wear out first. Between Boston and Chelsea the life of the rails is only 8 or 9 years.

MEMOIR OF DECEASED MEMBER.

ANDREW M. LOVIS.*

ANDREW M. LOVIS, son of Ambrose Lovis and Harriet (Howes) Lovis, was born in Boston on December 2, 1855.

He was educated in the Boston public schools and the Boston English High School, graduating with the class of 1873.

After leaving school, he entered the office of Thomas Doane, C.E., of Charlestown, Mass., remaining there for three years as student in engineering; then one year, 1876, as special student at the Massachusetts Institute of Technology; from 1877 to the fall of 1882 was connected with the Union Pacific Railroad on surveys and location of new lines in the Northwest; was transitman until 1881, then promoted to engineer in charge of surveys and location on the Utah North Railroad and Oregon Short line. In the winter of 1882 and 1883 he left the employ of the railroad and went to Europe for about a year. On his return he was connected with the Boston & Lowell Railroad as Assistant Engineer and in private business doing local engineering work from 1883 until 1895. For four years he was engaged in mercantile business.

In 1895, Mr. Lovis was appointed as Assistant Engineer in the Massachusetts Highway Commission. In 1900 he was made First Assistant Engineer, retaining that position until 1921, when he was made Bridge and Designing Engineer until his death on April 25, 1922.

Mr. Lovis was a member of the Boston Society of Civil Engineers, the American Association of Engineers, and the American Concrete Institute.

He married, in 1886, Miss Margaret A. Banks of Annapolis Valley, Nova Scotia, who survives him, together with one daughter.

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* Memoir prepared by A. W. Dean and John R. Rablin.

Mr. Lovis, in his twenty-seven years of public service, had done much toward the improvement and perfection of the method and results used and attained in the construction of highways and bridges throughout the Commonwealth of Massachusetts, and enjoyed the utmost respect of all those with whom he came in contact.

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COMMITTEE

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Walter H. Sawyer, Union Water Power Co., Lewiston, Maine.
Frank E. Winsor, Providence Water Board, Providence, R.I.
S. Stanley Kent, Proprietors of Locks and Canals, Lowell, Mass.

The object of the work being the collection, compilation and analysis of run-off figures for water power purposes, the Committee was made to include representatives of the engineering schools, of the Water Resources Branch of the U. S. Geological Survey, and of companies and engineering firms interested in water power.

Beginning with January 24, 1917, the Committee met frequently up to January, 1921. There was some interruption in the meetings during the early part of the war and the attendance at times has been small, due to a multitude of other engagements; but the Committee has met 33 times in all; there have been 16 meetings of sub-committees and in addition a great deal of work done through correspondence and individual calls by different members of the Committee.

There have been published by the New England Water Works Association two papers or reports of committees, with basic data to some extent like that which forms the subject of this report; and one paper on rainfall. These reports areas follows:

Yield of Drainage Areas (Report of Committee of N.E. W.W.A.) Vol. XXVIII (1914) page 397.

This report was written from the water works standpoint with particular reference to the dry period from 1908 to 1911. During this period the yield for 7 water works streams, most of them in New England and less than 100 sq. mi. in area, was 1.44 second feet per square mile. The average for the 10 years from 1911 to 1920 for the same stations was 1.66 second feet per square mile.

Data relative to awards for water and water power diversion (Report of Committee of N.E.W.W.A.) Vol. XXIV (1910) page 1.

This Committee published as basic data the average flow of the Sudbury River, 1.617 second feet per square mile in the

34 years from 1875-1908; the Nashua River, 1.829 second feet per square mile in the 12 years from 1897-1908; and the Croton River, 1.73 second feet per square mile for the 41 year period from 1868 to 1908. The averages for the same stations for the complete periods to 1920 are 1.52 second feet per square mile for the Sudbury; 1.67 for the Nashua and 1.665 for the Croton. The report consisted chiefly of a large amount of data relating to awards that have been made for damages resulting from the diversion of water.

Rainfall in New England, X. H. Goodnough, *Journal of N.E.W.W.A*. Vol. 29, (1915) page 237.

This paper covers admirably the source of run-off; and the supplementary report, bringing the figures for New England through 1920, was published in the *Journal of N.E.W.W.A.*, Vol. 35, No. 3 (September 1921).

The diagram in Mr. Goodnough's first paper showing progressive average rainfall in eastern Massachusetts 1749–1913 has been brought up to include 1920 and is reproduced in this report. (See Fig. 5.)

The earliest records of run-off in New England, most of them kept by water works or water power companies, are now available for nearly 50 years, but they are few in number. For the lack of more records they have been used by engineers over and over in design of water works, diversion cases and water power developments. Fortunately the care with which these early records were taken has made them reliable.

The scarcity of records outside of a few streams, most of them small ones, and the expense of getting an accurate record by water power companies led to the simpler methods and more comprehensive investigations of the U. S. Geological Survey beginning about twenty years ago. In New England many new stations have been installed and maintained for a longer or shorter period. The older water works and water power stations through the Survey bulletins have had the benefit of comparative records and special monographs on methods of making measurements and recording and publishing stream flow records. In addition records and papers on run-off and subsequent discussions by members of the engineering societies have helped to

make the records more available and the methods better understood. Even now, however, thoroughly reliable records, well scattered over New England, from which can be accurately determined the effects of cutting and subsequent growth of timber, the per cent. of precipitation collected in run-off, the point to which it is economical to spend millions perhaps in the development of water power on a given stream, the value of a given water power if taken away for water supply purposes, are not available. All of these problems require accurate long term records and more of them. More money should be appropriated for the U. S. Geological Survey work in New England, more precipitation stations installed, particularly in high altitudes, state maps should be completed, and water power operators and engineers should be willing to advise owners of water power that money for these purposes is well spent and necessary.

Within a very few years the main difficulties which heretofore have threatened the accuracy of run-off records—the effect of ice in winter, of daily fluctuations due to the use of pondage above the station, of backwater below the station, of shifting control, together with small errors which may be expected from types of instruments used, methods of handling and the human element in observers—have been more fully overcome than ever before; and, with money to do with and the more complete use of automatic gages and coöperation by owners of water power, it is hoped the next 10 years will see a tremendous improvement in the number and accuracy of the New England stations.

The Committee on Run-off has already published a Progress Report in the JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS, November, 1918. Most of the material was in the nature of papers by members of the Committee treating of matters which had been the subject of discussion at committee meetings. There are available several other valuable papers on other subjects which have been written by members of the Committee. These should appear in forthcoming JOURNALS of the Society.

SCOPE OF REPORT.

The full report of the Committee includes:

(*a*) A list of most of the published run-off records for New England with an index of where they can be found.*

(*b*) A grading or rating of these stations according to their relative accuracy.

(*c*) The compilation in full of 12 of the best and most representative of the longer term stations.†

(*d*) Representative hydrographs and duration curves.

(*e*) Duration tables for a large number of stations.*

(*f*) A map of New England showing the extent of the principal drainage areas, the location of the gaging stations and a selected number of rainfall stations with figures of the mean annual precipitation.

(*g*) A glossary of terms.

(*h*) A bibliography.*

The glossary of terms given with this report contains only the most important of them, and it is hoped by the Committee that new terms will be not added without very good reasons.

The Committee has, we believe, made a start towards bringing together run-off records collected primarily for water works and water power purposes and hopes this may be continued, as eventually engineers will require all the best records whether on small or large rivers, whether maintained for water works or for water power purposes.

The following is a complete list of all papers submitted to the Committee for discussion, most of them by members of the Committee:

"Glossary of Terms," by D. M. Wood.

"The Use of the Current Meter in Stream Gaging," by C. H. Pierce.

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* Not published in this report.

† These records not published in this report were as follows: St. John R. at Van Buren Me., 1908-1920; Penobscot R. at West nfield, Me., 1901-1920; Mattawamkeag R. at Mattawamkeag, Me., 1902-1920; Androscoggin R. at Rumford Falls, Me., 1892-1920; Presumpscot R. at Sebago Lake, Me., 1887-1920; Merrimack R. at Lawrence, Mass., 1880-1920; So th Branch Nashua R. at Clinton, Mass., 188 - 9 ; Souhegan R. at Merrimack, N. H., 1909-1920; Connecticut R. at Orford, N. H., 1900-1920; Deerfield R. at Charlemont and Shelburne Falls, Mass., 1907-1920; Housatonic R. at Falls Village, Conn. 1912-1920; Lamoille R. at Cadys Falls, Vt., 1913-1920.

"0.2 and 0.8 Method of Current Meter Measurement in Power Canals," by A. T. Safford.
"Precipitation, Evaporation and Run-off," by A. T. Safford.
"The Effects of Ice on River Discharge," by C. H. Pierce.
"Methods to be Used in Compilation of Data," by C. H. Pierce and D. M. Wood.
"Snowfall," by H. S. Boardman.
"Use of the Venturi Meter for Run-off Measurements," by Clemens Herschel.
"The Human Element in Gage Reading," by C. W. Sherman.
"Flood Measurements," by D. M. Wood.
"Inspection and Tests of Run-off Records," by C. H. Pierce.
"Classification—Factors Affecting Run-off Records," by D. M. Wood.

Suggestions and criticisms of the work of the Committee or answers to questionnaires have also been received on questions submitted by the Committee from the following engineers to whom the thanks of the committee are extended.

A. S. Addison	Desmond Fitzgerald	C. A. Mixer
M. G. Barnes	J. R. Freeman	Dwight Porter
H. K. Barrows	F. L. Fuller	C. M. Saville
P. L. Bean	G. F. Hardy	J. W. Smith
Clinton Bogert	Clemens Herschel	Earl Stafford
H. F. Bryant	R. E. Horton	F. P. Stearns
C. E. Chandler	I. E. Houk	J. L. Tighe
H. L. Coburn	H. J. Hughes	H. M. Turner
A. S. Crane	C. T. Main	J. F. Vaughan
E. A. Ekern	F. H. Mason	A. E. Winslow
H. S. Ferguson	I. W. McConnell	C. O. Wister

The Committees sought to determine the preference of hydraulic engineers in regard to the publication of run-off records, whether by calendar years, or on a climatic year basis as used by the U. S. Geological Survey. The majority of replies received somewhat favored the calendar year. However, in view of the fact that most of the records used in water power practice are published in the Water Supply Papers of the U. S. Geological Survey and are on a climatic year basis, and that future records and duration tables will become available in that form, it seemed

best to the Committee to adopt this method although the Committee regrets the necessity for this change from the calendar year.

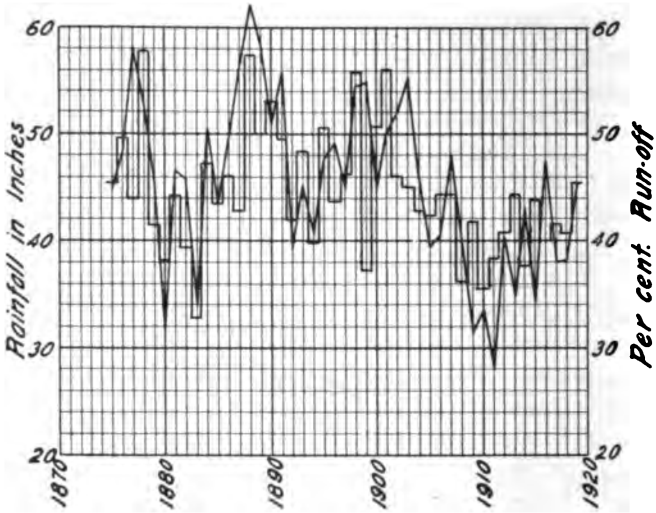
With the hope of helping to answer some of the open questions concerning the amount and distribution of run-off in New England the Committee has gathered data for a number of streams for which the annual run-off in second feet per square mile is given by way of summary in Appendix A, page 182.

The long term records show that the ten year period from 1911 to 1920 is a very valuable one for run-off records and fortunately many new and good records have been obtained during this period. The period is one of from average to very low rainfall and remarkable in every way.

The principal questions concerning run-off which have been asked of engineers during the past 50 years and about which a great many controversies and discussions have raged and will continue to rage, are:

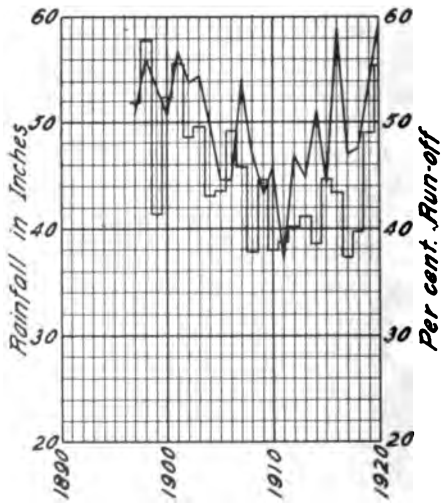
RAINFALL AND RUN-OFF.

The effect of increased amounts of rainfall to increase the per cent. of run-off. The results clearly indicate that broadly speaking an increase of rainfall does materially increase the per cent. of run-off. On the Sudbury and Wachusett watersheds 40 in. of rainfall corresponds to about the same per cent. of rainfall collected; while 60 in. of rainfall increases this per cent. of collection by 50 per cent. The drainage area above the Merrimack River at Lawrence, Mass., shows a similar tendency with a somewhat higher ratio of run-off to rainfall, which may be partly due to lack of high altitude rainfall stations in that basin. Individual years show marked discrepancies, due probably to differences in the amount of ground storage carried over from year to year and to differences in the distribution of the rainfall during the year and the conditions under which the precipitation took place, but the general trend is distinctly as stated above. A diagram (Fig. 1) of the rainfall and run-off of the Sudbury and Wachusett watersheds of the Metropolitan Water Supply is submitted to illustrate this point.



Sudbury Drainage Area

Rainfall in inches shown thus:
Per cent. run-off shown thus:



Wachusett Drainage Area

Fig. 1 — Annual Rainfall And Per Cent. Run-off.

COMPARISONS BETWEEN RUN-OFF RECORDS.

The Committee deems it expedient to call attention to two interesting methods of making comparisons between run-off records, because they are not in common use and do bring out important facts.

One method has been suggested (Stone & Webster JOURNAL for February 1917) by which the relative distribution of run-off at two stations may be studied, and which sometimes indicates an unsuspected similarity between the run-offs at the two points.

This method is illustrated by Figs. 2 and 3 of this report, which furnish a comparison of the run-off of the Connecticut River at Holyoke and at Orford, with the Merrimack River at Lawrence for the period of years common to the records. The method consists in taking off from the duration curves of flow for each station the flows corresponding to say each 5 per cent. increment of time on the "per cent. of time" scale, and computing their ratio to the respective long term average flow for each station. These results are then plotted in the form of curves, as illustrated. The vertical scale is, therefore, a relative scale (it can be a "per cent. of average flow" scale if desired) instead of an absolute scale of second feet per square mile.

This method results in a comparison of the relative distribution of run-off regardless of the size of drainage area or the disparity between average flows at the stations. In the cases shown there is a surprising similarity in the relative distribution in spite of the differences in drainage areas and average unit run-offs.

As further indicating the variations in annual run-off to be expected on the same stream at different points of the drainage area and hence indicating the value of the foregoing method of comparison, Fig. 4 is attached, which gives a second method of comparison and one which indicates clearly the variation in average long term run-off on the Connecticut River. This curve illustrates the fact generally found on all New England streams, — that average run-off increases materially as the size of drainage area decreases or as the station is moved from the mouth toward the source, from low to high altitudes. This fact can readily be shown graphically as in the instance given.

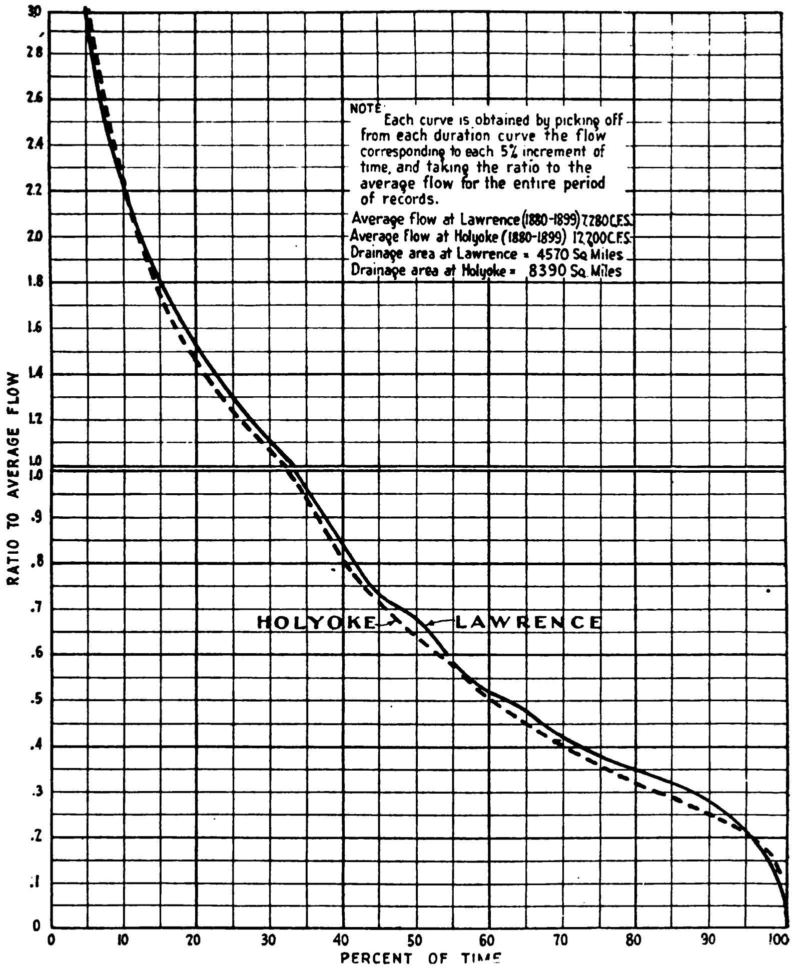


FIG. 2 — COMPARISON OF RUN OFF.

Connecticut and Merrimack Rivers at Holyoke and Lawrence.
Period — October, 1880 to September, 1899.

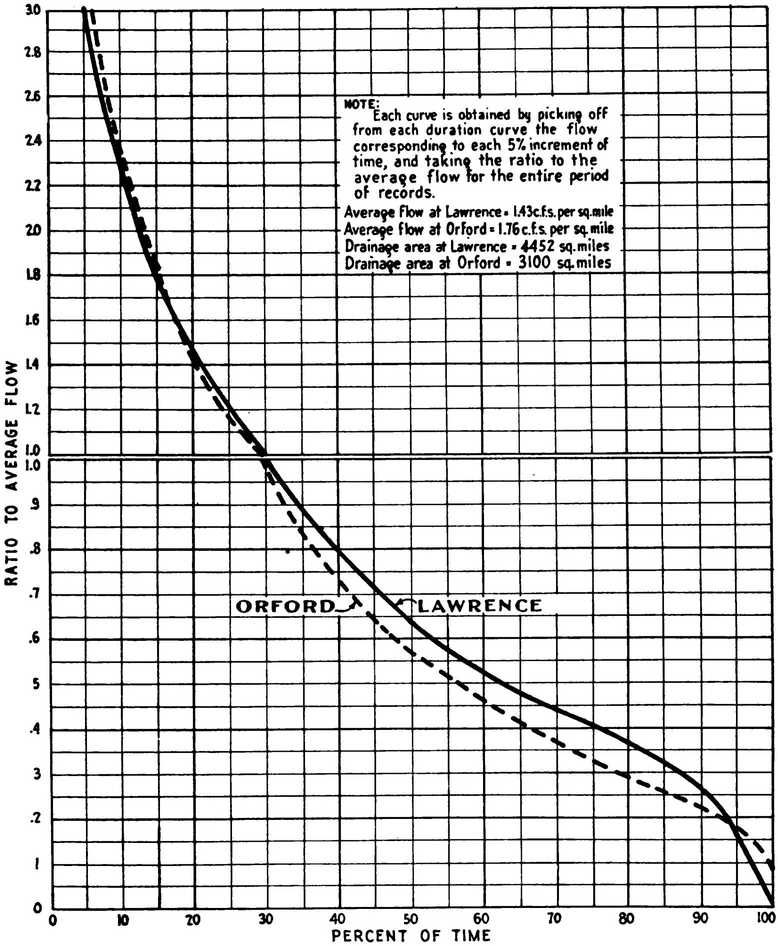


FIG. 3 — COMPARISON OF RUN-OFF
Connecticut and Merrimack Rivers at Orford and Lawrence.
Period — October, 1900 to September, 1920.

This second method indicates clearly the important point that the often used theory of applying the same unit run-offs at one station to another locality some distance away in the same watershed is wrong, and if employed is likely to lead to erroneous conclusions. Similarly, much more care is necessary in ascertaining relative conditions if the unit run-off in one basin are to be applied in contiguous basins.

Variations and apparent discrepancies in records for stations on the same river can usually be explained by differences in rainfall on the drainage areas above the stations; but variations or defects in records at one station due to pondage, ice, raising or lowering of flashboards, etc., can be explained only by an intimate knowledge of the operation of each station, by long continued observations and more of them in a day. Many of the best stations are not available for long term comparisons due to the absence of continuous winter records.

LARGE AND SMALL STREAMS.

The increase in unit run-off as the drainage area decreases indicated in the preceding paragraphs brings up the question of the effect of the size of the drainage area. Although the results are not conclusive, it appears that such increases are due chiefly to other causes than the size of the tributary drainage area. Such precipitation and stream flow records as are available support the statement that, other things being equal, run-off increases with altitude in New England. If this is true it follows that the unit run-off will increase as the source of a stream is approached. On the other hand tributary streams at low altitudes in the lower part of drainage basins frequently have a lower yield than the main river, thus proving that the size of drainage area is not the controlling factor. Six small streams with low altitude drainage areas in the 10 years from 1911 to 1920 averaged 1.44 second feet per square mile while for the same period six large streams averaged 1.75 second feet per square mile.

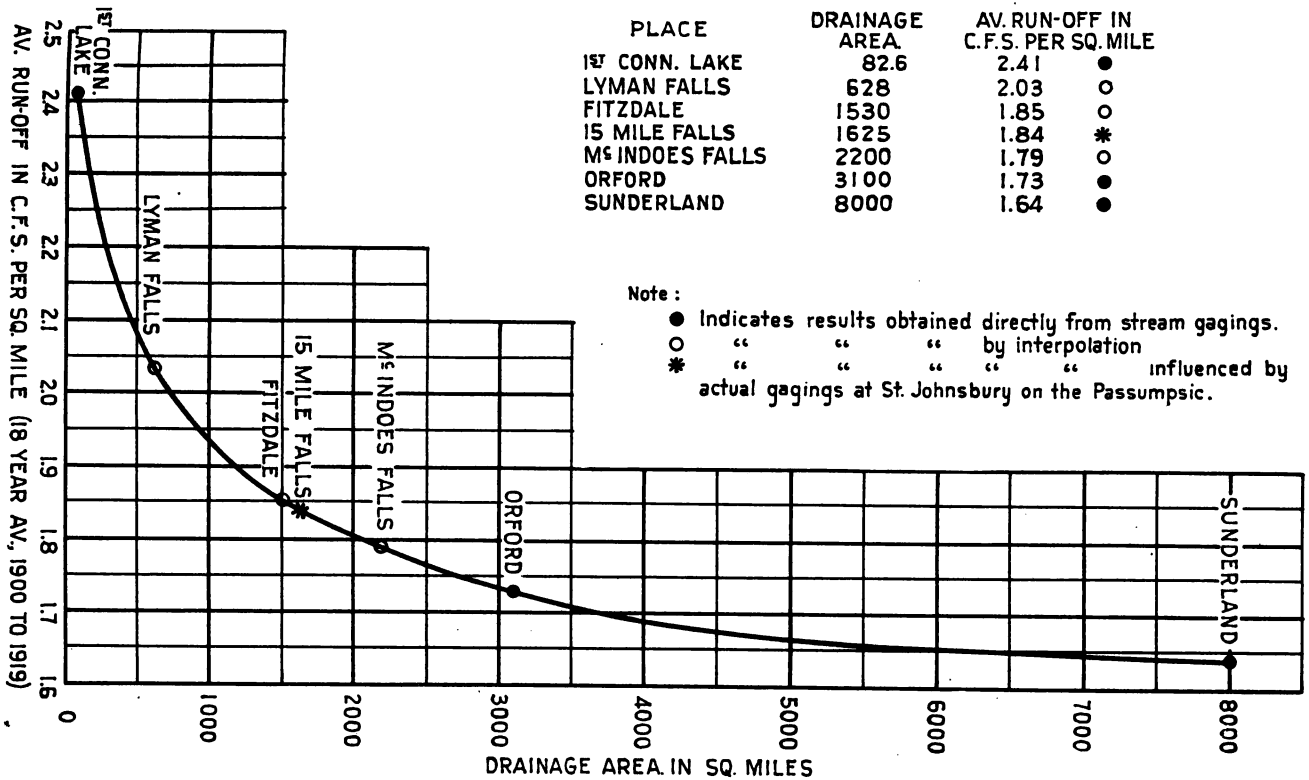


FIG. 4 — RELATION OF RUN-OFF TO DRAINAGE AREA.
Hydraulic Studies of Connecticut River.

PRECIPITATION RECORDS.

The progressive average rainfall, particularly for eastern Massachusetts in the 18th century, shows relatively but little greater differences in the precipitation than in the 19th. What long term records of run-off we have appear to bear out the fact that there are no greater differences in the flow than exist because of the differences in rainfall. The diagram Plate XXIII in the paper by X. H. Goodnough already referred to is given by way of illustration. (See Fig. 5.)

Precipitation stations, while numerous when shown on a map of New England, are located for the most part in the valleys. The number of high altitude stations should be much increased. One engineer has suggested a precipitation station in every township of 36 square miles.

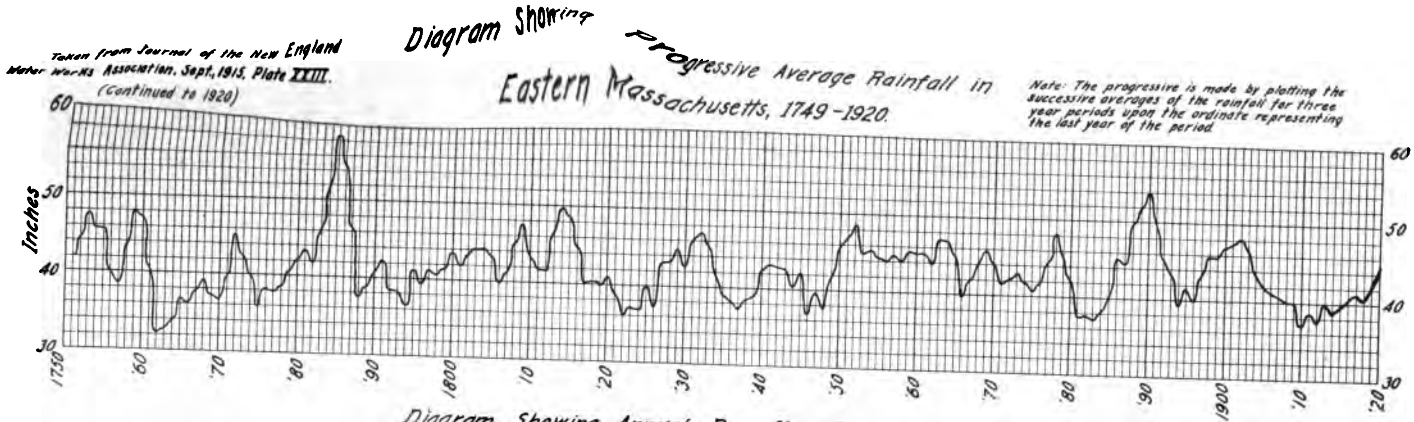
The run-off in inches on the drainage area is a figure which should prove useful in many cases to water works and water power engineers using run-off records. The "per cent. of run-off" has little value where the precipitation of several thousand square miles is represented by one or two stations. The value of per cent. of run-off figures will be much increased when the precipitation stations fairly represent the drainage areas.

SNOW COVER.

The snow cover at the end of each winter month becomes important on account of its possibilities for good or evil. The freshet is always the one menace to the engineer who tries to save money in the construction of coffer and masonry dams and other heavy structures across our great rivers; but the same snow may be converted into the best kind of insurance in the way of water storage. The Committee suggests that some standard form of snow record be adopted, and recommends that surveys be made and snow records be maintained as important.

EVAPORATION.

Very little new material on evaporation has been at the disposal of the Committee. Whatever we have may probably be taken as equivalent to the Chestnut Hill, Mass., records reduced


Taken from Journal of the New England Water Works Association, Sept. 1915, Plate XXIII. (Continued to 1920)
Diagram Showing Progressive Average Rainfall in Eastern Massachusetts, 1749-1920.
Note: The progressive is made by plotting the successive averages of the rainfall for three year periods upon the ordinate representing the last year of the period.
Inches
60
50
40
30
1750
'60
'70
'80
'90
1800
'10
'20
'30
'40
'50
'60
'70
'80
'90
1900
'10
'20

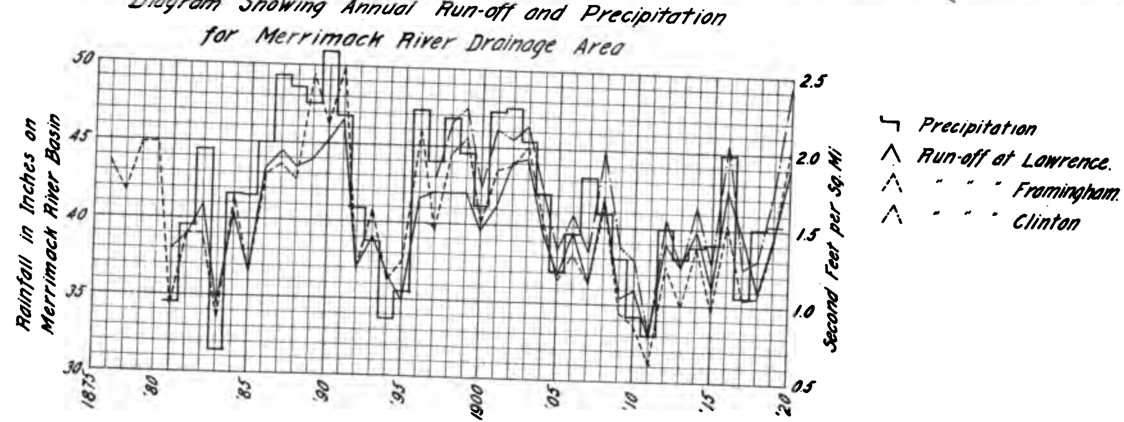


Diagram Showing Annual Run-off and Precipitation for Merrimack River Drainage Area
Rainfall in Inches on Merrimack River Basin
Second Feet per Sq. Mi.
50
45
40
35
30
2.5
2.0
1.5
1.0
0.5
1875
'80
'85
'90
'95
1900
'05
'10
'15
'20
Precipitation
Run-off at Lawrence.
" " " Framingham.
" " " Clinton

FIG. 5.

by an amount equal to about 1 in. of evaporation per month to 9 degrees Fahr. of temperature which of course refers only to a climate like that of New England. Tables of evaporation which apply to New England are offered as far as they are available.

TABLE 1.

EVAPORATION IN INCHES FROM WATER SURFACE AT CERTAIN LOCALITIES IN NEW ENGLAND AND NEW YORK, BY MONTHS

	Chestnut Hill, Boston, Mass. In.	Maine, Composite Figures. In.	Fall River, Mass. 1899-1901 In.	Mt. Hope Reservoir, Rochester, N. Y. 1891-1907* In.
January	0.96	0.70	1.24	0.75
February	1.05	0.70	1.10	0.79
March	1.70	1.10	2.05	1.44
April	2.97	1.60	3.27	2.61
May	4.46	2.10	4.59	3.74
June	5.54	2.80	6.13	4.52
July	5.98	4.32	5.91	5.14
August	5.50	5.00	4.73	4.86
September	4.12	3.32	4.08	3.86
October	3.16	2.20	2.73	2.74
November	2.25	1.30	1.66	1.52
December	1.51	0.70	1.23	1.16
The Year	39.20	25.84	38.72	33.13

MEASUREMENTS.

Controversies over methods of measurement, average velocity, types of current meters and the many and varied steps which go to make up a rating curve and its consequent use, should no longer exist. Engineers have agreed that for general use the current meter is the quickest and best method of measuring water running through a given cross section. When properly used and the velocity through the entire channel covered in one way or another, the rest is usually a matter of mathematics. The human element, which is such a very important element in obtaining accuracy, can be kept up to the mark only by con-

* Records for July, Aug. Sept. and Oct. began in 1891, for May and June in 1892, for April in 1894, for Nov. and Dec. in 1895 and for Jan., Feb., and Mar. in 1896.

stant supervision on the part of some central authority like the U. S. Geological Survey.

The maximum and minimum flows, important as they are for purposes of rating a station and study of the records, are rarely obtainable because of the difficulty of knowing when to anticipate these conditions; and of making measurements at times of freshets and droughts.

For water wheel tests and measurements which appear to warrant the large expense of getting ready special apparatus, the weir, the Venturi meter, the chemical method and many others will be gradually standardized for use.

Many water power station records require a careful rating of the dam and flashboards. With many of our rivers 50 per cent. of the total flow of the year goes by the station in the form of waste. It is probable that the largest element of uncertainty and one which oftentimes rules out a station record is the absolute lack of intelligent coefficients covering the waste over dams and through gates.

Experiments on a large scale and with actual structures and velocities approaching them should be made and these dams, flashboards and gates should be rated with a fair degree of accuracy. Too much time has been spent upon model sections and orifices.

EFFECT OF PONDAGE.

The pondage of water in many of our streams has heretofore been responsible for a great many relatively high figures of run-off. The "concentration factor" or ratio of the use of water during working hours to the 24 hour flow may vary from 1 to nearly 3 where the water is ponded as it is at Lowell or Lawrence. The 24 hour flow at such a point is usually difficult to estimate unless special arrangements are made to get the average flow. This is also true of many stations on small streams where the effect of pondage above, though small, may still be enough to make valueless the records of run-off of these streams. These difficulties are now generally overcome by the use of automatic water stage recorders or by more frequent readings.

WINTER RECORDS.

Many of the winter records which have been obtained in the past under ice conditions are viewed with suspicion and many otherwise good stations have been defective in this respect. The Committee believes that the method * of correcting the gage heights for backwater produced by ice, the amount of which can only be determined by frequent winter discharge measurements, represents a distinct advance in the science of stream gaging under ice conditions and that the winter records have been much improved since about 1915, when this method came into general use. A diagram (Fig. 6) is given as an example of the application of this method. A gaging station at which a complete ice cover remains unbroken throughout the winter will give the best results by this method. The presence of anchor ice and the unstable conditions existing during the formation or disappearance of the ice cover make for uncertainty and during such periods accurate records can only be obtained by means of frequent discharge measurements.

HYDROGRAPHS AND DURATION CURVES.

The hydrograph may be considered a desirable preliminary step to a study of run-off records and is recommended by the Committee.

The duration curve or table has been selected as one of the best means of showing the record of a given river; but the Committee has found that yearly duration curves or tables are much more comprehensive and are less misleading than an average. In this connection a study of five year periods or a series of dry and wet years is valuable.

EFFECT OF DEFORESTATION.

The effect of cutting the forests and of subsequent growth upon the flow of streams is not clear, and the question has for many years been under discussion. The work of this Committee has not included a study of this problem as it alone might well

* See paper on "The Effects of Ice on River Discharge." in the preliminary report of this Committee, JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS, November 1918.

involve an intensive investigation. Very broadly speaking, it may be said that results of a conclusive nature can only be obtained by an intensive investigation, in which preferably two small adjacent areas, one forested and the other deforested, are compared. These areas must, so far as practicable, be so located with reference to prevailing storms, topography, geology and all other contributing factors except that of forestation, that any detectable difference in run-off may fairly be attributed to the relative forestation. Theoretically, large areas might be studied, but the lack of reliable long term run-off records covering different degrees of forestation makes any deductions uncertain.

The results from the 12 stations studied by this Committee bear out in a general way the foregoing statements; but there should be an additional ten year unbroken record for many of these stations before definite conclusions can be drawn.

IMPORTANCE OF RECORDS.

The interest which engineers and members of the New England Water Works Association have in run-off records should be merged with the interest of water power engineers. The use of measurements on streams of considerable size is becoming more and more important to the public, engineers and water power owners with the increasing value of water power. On many streams the absolute minimum for steam, washing and process purposes has a value way in excess of its value for power. Equipment is now being installed in many cases double that of ten years ago; and while some of it lies idle for a part of the year, yet these larger installations reduce the coal bill during many months. A merely conservative small figure no longer interests the engineer, but rather figures more favorable to the use of water power. Waste waters and their possibilities are being studied for water storage and the flow available for each tributary stream must be known in advance.

Every water power owner ought to agree to maintain a first class station at his own plant if possible; or if conditions will not allow this, ought to be willing to share with others the expense of maintaining a first class station on his river, including precipitation stations, particularly high altitude ones.

The Committee submits its work with the hope that all of the material submitted may be of value to the Society and a large part if not all of the report may be published.

Respectfully submitted,

ARTHUR T. SAFFORD, *Chairman*
C. H. PIERCE, *Secretary*
HAROLD S. BOARDMAN
A. C. EATON
X. H. GOODNOUGH
RICHARD A. HALE
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CHARLES W. SHERMAN
W. F. UHL
FRANK E. WINSOR
D. M. WOOD

MARCH 16, 1921.

APPENDIX B.

GLOSSARY OF TERMS.

1. **Precipitation** is water that passes out of the atmosphere, in liquid or solid state, to the surface of the earth or bodies of surface water. It includes rain, snow, hail, sleet, dew and frost, mist and fog. It is the process by which atmospheric moisture becomes surface water. Rainfall and snowfall make up precipitation as ordinarily used.

(*a*) **Rainfall** is sometimes used in the sense of " precipitation," but it should become more general practice to limit its use to atmospheric moisture precipitated in the form of rain. Its common use in the broader sense undoubtedly is the result of the practice of measuring all forms of atmospheric precipitation in terms of " inches of rainfall."

(*b*) **Snowfall** is considered as snow, hail, sleet and other forms of precipitation, except rain, measured in depth in inches as it falls, but usually appears in records as its water equivalent.

(*c*) **Snow residuum** is the accumulated snow on the ground surface at the end of any period, or its water equivalent.

(*d*) **Water equivalent** is the depth of water in inches to which the snow on a given area would melt.

(*e*) **An isohyetal map** shows variation in amount of average precipitation over contiguous areas and isohyetal lines are used to connect contiguous points of equal precipitation, similar to contour lines.

2. **Evaporation** is the return of water from the earth or water surface to the atmosphere. It takes place in three or more ways, as from —

(*a*) Water, ice and snow surfaces; (*b*) land surfaces; and (*c*) vegetation, in the form of transpiration. Both evaporation and precipitation are the results of differences in temperature and atmospheric pressure.

3. **Seepage** or **percolation** of water is the movement of water underground, produced by hydrostatic pressure. Seepage waters reappear at the surface.

4. **Absorption** comprises all processes by which water is taken up by the earth's surface.

5. **Leakage** is the movement of water through artificial structures, and is produced by hydrostatic pressure.

6. **Discharge** is a general term for the rate of flow of water. In water-power practice, it is usually expressed in cubic feet per second (frequently abbreviated to second-feet); in water-works practice, it is customarily expressed in terms of million gallons per twenty-four hours.

7. The **drainage area** of a stream at a given point is the area of the surface of the earth which contributes its run-off to the stream above that point. Synonyms: Catchment area, watershed. (The latter is a misnomer as it is confused with the divide or boundary of the basin). The area used may be either gross, or the net exclusive of lake and pond areas, but it is assumed to be the former unless specified to the contrary.

8. The **run-off** of a given area of the surface of the earth is the quantity of water that is discharged from that area. Ordinary units of run-off are second-feet per square mile or run-off depth in inches.

(*a*) **Cubic foot per second** or **second-foot** is a unit of discharge of water flowing in a channel of one square foot in cross section at an average velocity of one foot per second.

(*b*) **Second-foot per square mile** is a unit of discharge indicating the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the run-off is distributed uniformly both as regards time and area.

(*c*) **Run-off depth in inches** is a unit of run-off indicating the depth to which the drainage area would be covered if all of the water flowing from it in a given period of time were conserved and uniformly distributed on the surface. It is used for comparing run-off with precipitation, which is usually expressed in depth in inches.

9. The **yield** of a drainage basin above any definite point is the collectable portion of the surface and underground waters. Any retention or detention of these waters within the drainage area, either naturally or artifically, varies the relation of yield to run-off.

Units of yield are the same as for run-off. In water-works practice, the terms " million gallons per day " or equivalents are used.

10. **Storage.** The word usually means —

(*a*) **Artificial storage** which is that water capacity which may be available to increase the extremely low flows for several days, weeks, months or even years. It is the retention of the flood waters for use during times of scarcity, and is usually located near the headwaters of a stream. Units for storage are million cubic feet, million gallons and acre-feet.

(*b*) There is usually some **natural storage** in the form of swamps, lakes and ponds, but its effect on stream flow cannot easily be separated from that of the rest of the drainage area. The same applies to ground water storage and stream channel storage.

11. **Pondage** is that water capacity created by any dam which tends to take care of the variations in draft at a water-power development. It is the retention for one or more days of the flow of a stream during hours of light load, for use during hours of heavy load.

12. **Factors:**

(*a*) **Load factor** is the ratio of the average to the maximum power load on a water-power plant during a given period of time, as a day, month or year. To be specific, this period should always be stated, as " daily load factor," etc. Frequently when plants operate for a period less than twenty-four hours, the load factor is expressed in terms of " load factor for hours when running;" but for purposes of stream-flow analysis all such factors should be reduced to the twenty-four hour basis.

In determining load factor, the " maximum load " should be the heaviest observed during the period. Usually, daily log records are kept, and switch-board instruments, when available, are read every half hour, or hour, and the highest of these observations is taken as the maximum.

The " average load " is the total energy output divided by the proper time unit.

(*b*) **Capacity factor** is the ratio of the average load in a given time period, as a day, to the total installed rated capacity of the equipment.

(*c*) **Utilization factor** is that coefficient by which the approximate theoretical energy-output must be multiplied to correspond to the actual delivered energy. It accounts for losses of all kinds, and for variations in operating conditions other than those included in the theroretical average plant efficiency.

The approximate **energy available** in a stream can be estimated by the following formulas:

I. Net horse-power at the water-wheel realizing 80 per cent. of the theoretical power $= \dfrac{\text{cubic feet per second x head}}{11}$

If other than 80 per cent. is used as the efficiency of the equipment, then the formula should be —

$$\text{Net horse-power} = \frac{\text{cubic feet per second x head x efficiency}}{8.8}$$

II. Electrical horse-power (73.3 over-all efficiency) =

$$\frac{\text{cubic feet per second x head}}{12}$$

or,

$$\text{III. Kilowatts} = \frac{\text{cubic feet per second x head}}{16}$$

Losses allowed for in the utilization factor are leakage and waste in operation, etc.

Changes in efficiencies may be due to variations in load or variations in head from the average assumed for use in the formulas.

(*d*) **Concentration factor** is the ratio of the average flow during that part of the day pondage is being drawn upon to the 24 hour flow. The term is used as a measure of the increased flow made available at a given power development during part of the day as a result of the use of pondage.

(*e*) **Diversity factor** is the ratio of the sum of the maximum power demands of the subdivisions of any system or part of a system to the maximum demand of a whole system or part of a system under consideration, measured at the point of supply. The more noncoincident these peak surfaces are, the greater will be the diversity factor.

Apparent Diversity factor is the quotient obtained by dividing the total connected load by the station peak load. **True Diversity Factor** takes account of transmission losses.

(*f*) **Demand factor** is the maximum connected kilowatts of capacity divided into the actual kilowatts of demand, expressed in terms of per cent.

(*g*) **Peak** is the highest average load carried during one minute of any specified period. **Peak load** is the highest average load during one hour of any specified period.

13. **River gaging stations.**

(*a*) **Control** is the natural or artificial barrier, reef of ledges or other channel conditions below a gaging station which primarily affects and controls the relation between gage height and discharge at the station. It should be noted that the control may not be the same section for all stages.

(*b*) **Rating table** for a gaging station is a table showing the discharge corresponding to various gage heights at the station.

(*c*) **Rating curve** for a gaging station is a curve of relations between gage height and discharge.

(*d*) **Stage-discharge relation** is the relation between gage height and discharge as shown by the rating curve, q.v.

(*e*) **Water-stage recorder** is an instrument for automactically recording the elevation of the water surface, and the corresponding time.

14. **Regulation** is the artificial manipulation of the run-off of a stream.

15. **Fall** is the vertical distance between water surface levels at two points on a stream.

(*a*) **Gross head** is that portion of the fall which is available for producing power.

(*b*) **Net** or **effective head** is the residue left to produce energy after deducting all losses of head. These losses may be due to friction, irregularities of section and other causes.

(*c*) **Slope** is the total fall between two points divided by their distance apart, expressed in the same units.

16. **Dams:**

(*a*) **Crest of a dam** is, in general, the elevation at which overflow begins.

(*b*) **Height of a dam** should be specifically defined as either: (1) from the bottom of foundations, or (2) from the original bed of the river, to the crest or top of the dam. Top of the dam is used when there is no overflow.

17. **Backwater.** — This is the general term applied to the raising of water upstream from an obstruction to higher elevations than it would stand under similar conditions of flow with no obstruction. Such an obstruction may be a permanent structure like a dam or bridge pier, or may be a temporary obstruction like ice or logs. An unusually heavy discharge from a tributary may cause backwater in the main stream or vice versa.

(*a*) **Backwater curve** is a profile of the water surface upstream from an obstruction between such obstruction and the point where the backwater ceases. Such a curve or profile is used in determining the elevation of the water at any point under known or assumed conditions of flow. Each different set of conditions produces a different backwater curve.

(*b*) **Backwater effect** is the increase in water-surface elevation caused by an obstruction, and varies with the discharge. It may be obtained at any point by a comparison of the backwater curve and the natural profile of the stream with no obstruction, each referred to the same discharge. In discussions on this subject the term backwater effect is sometimes shortened to backwater.

18. An **average year** is frequently assumed to be that year obtained by averaging the duration curves for all the years. Otherwise, it is assumed to be that actual year in which the average natural run-off is the nearest to the arithmetical average for the entire period of record.

APPENDIX C.

GRADING OF NEW ENGLAND RUN-OFF RECORDS.

The grading or rating of run-off records in accordance with their relative accuracy has been found to be a difficult task. To recognize the fact that some run-off records have been more carefully and accurately kept than others, and that such records are more reliable and more useful was a simple matter for the Committee, but to devise a system by which records could be more or less automatically graded according to their reliability was much more difficult.

The chief difficulties in the way of grading records may be stated as:

1. Lack of intimate knowledge of all the stations. Factors or conditions having a marked effect on the accuracy of records may be unknown. New information bearing on the accuracy of past records has frequently come up, and presumably will continue to do so.
2. The difficulty of accurately balancing the importance of various items, as for example the relative weights of (1) a shifting control, (2) winter records based on estimates, and (3) the effect of say two readings a day with a fluctuating stage.
3. Difficulties of intercomparing records at different stations in view of the different conditions and circumstances under which records are obtained.

As a result of these difficulties the Committee came to the following conclusions:

1. That any rating giving the **percentage accuracy** of the records was manifestly impossible and that the grading must be according to **relative accuracy.**
2. That the relative grading as thus obtained in nowise constitutes the last word upon the records considered, but rather represents the best judgment of the Committee based upon the information available.
3. That there is no reason why accurate records should not be obtained at both open channel stations and stations at dams and power sites, and it has been arbitrarily assumed that the best records at the two kinds of stations are about on a par.

The system of grading finally adopted was based upon the principle of penalizing records a certain amount for each defect by which they fail to measure up to a perfect standard. The requirements necessary for accurate records were first classified with great detail and opposite each item was set an estimate of limiting penalties, the idea being that the worst case to be considered might be penalized an amount indicated by the upper limit.

Upon attempting to apply the system as thus worked out, it was frequently found difficult to decide under just what item a deduction for a given defect should be made. Hence, as a working proposition, it developed that all the deductions could best be made under the following general headings:

A. Open channel gaging stations.
   1. Rating curve, how well defined.
   2. Limits defined by discharge measurements.
   3. Effect of ice, weeds or logs.
   4. Records of stage, accuracy and frequency of readings.

B. Stations at dams and power plants.
   1. Discharge measured by water wheels.
   2. Normal discharge over dam or through waste gates or waste weirs.
   3. Flood flows.
   4. Records of stage and gate openings.

As the grading was further considered it became evident that many of the records were not of the same quality or degree of accuracy for their entire length. This is particularly true of open channel gaging stations on account of the marked development in the science of stream gaging during the last twenty years. The work of the U. S. Geological Survey in New England began about 1900 and much of the stream gaging work prior to 1911 or 1912 was of a reconnaissance nature. During this early period many difficulties in the way of good records were encountered and largely overcome by the use of the automatic gage, better methods of handling winter records as outlined in the monograph on that subject in the preliminary report of this Committee, and generally improved methods of stream gaging

work. Where proper, the grading has been divided into periods to correspond to these improvements.

The actual method of grading was as follows: For each open channel gaging station, a station description, list of discharge measurements up to 1920, and footnotes to daily and monthly discharge tables were assembled. Additional information was obtained from the station diaries kept at the U.S. Geological Survey office. The discharge measurements for the entire period were plotted both for the curve as a whole and also the lower section on a greatly enlarged scale, using different colors and symbols to designate the measurements of each year. For stations at dams and power sites, all published information was gathered together and additional information sought from the men most closely connected with the records. Each station was then considered in turn and deductions made under the four general headings.

The final rating of a record was obtained by adding together all the penalties and deducting from 100. The numerical result thus obtained was changed to a letter basis in order to avoid possible confusion in the meaning of the grading, and to prevent attempts to use the numerical rating as designating the limits of accuracy. The results of the grading have been stated as varying from A to D, A representing the best records and D the poorest. In addition a brief comment has been added in an attempt to characterize each record.

The Committee desires to make acknowledgement to Mr. P. L. Bean, former Chief Engineer of the Maine Public Utilities Commission and to Mr. G. C. Danforth, Chief Engineer of the Maine Water Power Commission for valuable information and assistance given by them covering the records in the State of Maine.

It should be stated that no reflection is intended or is attached to a low rating. In all cases of records furnished by private individuals or companies these have been given out freely for the benefit of the general public. These records have usually been obtained for specific purposes in connection with the operation of power plants. They are usually simply a side issue in the conduct of a power business and the accuracy of such records largely depends upon the local conditions.

Any consideration of the accuracy of run-off records naturally brings up the question of the uses of such records. These may be stated as follows:

(1) for estimating the power output obtainable from undeveloped water power sites and deciding upon the size of installation and cost of construction warranted.

(2) for estimating the maximum floods for which provision must be made.

(3) for determining the size and benefit derivable from a proposed storage reservoir for power, water supply or flood control purposes.

(4) for determining the best method of operating reservoirs and power plants already constructed and estimating future results.

(5) for estimating the value of diversions.

(6) for studying the science of hydrology.

In some cases the minimum flow may be required, in many instances the intermediate part of the duration curve for the purpose of estimating secondary power is of chief interest, while in other cases the total run-off, the distribution, the length and amount of the flood flows involving backwater; or some other special knowledge of run-off conditions may be desired.

A record which is given a low rating may nevertheless be of much value for some and possibly all of the uses listed above. In general, however, it is intended that the higher the rating of a record, the greater the confidence which may be placed in it.

Results of Grading.

Station.	Period.	Grade.	Remarks.
St. John Rivfr Basin.			
1. St. John R. at Fort Kent, Me.	1905–15	D	Rating curve well defined below 15,000 sec. ft. Records missing, or affected by log jams or ice an average of 5 months per year.
2. St. John R. at Van Buren, Me.	1908–20	A–	Open water rating curve extremely well defined, though no check measurements since 1915. Discharge during winter based on gage heights at Grand Falls and rating curve derived from measurements at Van Buren. Comparison of Van Buren and Grand Falls gage heights during open water period of 1916 showed Grand Falls record 11.9 per cent lower than Van Buren record.
3. Aroostook R. at Fort Fairfield, Me.	1903–10	C	Open water rating curve well defined and open water records good. Stage affected by ice, or gage heights missing from 4 to 6 months each year during which records missing or based on rough estimates.
St. Croix River Basin.			
4. St. Croix R. near Woodland, Me.	1902–11	D–	Rating curve defined by few measurements. Discharge relation affected by ice or log jams during much of year. Fluctuations in stage caused by mill after 1906. Gage read twice a day.
Machias River Basin.			
5. Machias R. at Whitneyville, Me.	1903–15	C	No effect from ice usually assumed, though records since 1916 show ice effect from two to four months each winter. Operation of storage dam 200 ft. above gage causes considerable daily fluctuation during low stages. Some log driving and jams of short duration. Gage read once a day.
	1916–20	B–	Winter estimates based on backwater effect of ice. One to three discharge measurements each winter.
Union River Basin.			
6. W. Branch of Union R. at Amherst, Me.	1909–13	B–	Open water records fairly good, though occasional log jams occur, and lower part of rating curve is only fairly well defined. Discharge relation affected by ice 2 to 4 months each year, when records based on rough estimates.
	1914–19	B	One to three discharge measurements each winter and estimates during ice conditions based on gage heights corrected for backwater.
Penobscot River Basin.			
7. West Branch of Penobscot R. at Millinocket, Me.	1901–20	B	Only monthly figures available. When flow is below 2 500 sec. ft., all the water generally flows through the wheels of the mill which have been carefully rated. Records corrected for storage.

8. West Branch of Penobscot R. near Medway, Me.	1916–20	A –	Rating curve well defined although the control shifted in 1917 and again in 1920. Effect of ice not great. Some trouble with gage heights previous to 1919.
9. Penobscot R. at West Enfield, Me.	1902–13	B –	Rating curve well defined and open water records fairly good. Discharge relation affected by ice 3 to 4 months each year, during which records are missing or are based on rough estimates. Two gage readings a day previous to 1912. Some daily fluctuation. Passadumkeag R. enters below the station, but above the control. (Passadumkeag Rips.)
	1914–20	A	Rating curve well defined. Automatic gage. Winter estimates ascertained by comparison with records at Sunk Haze Rips, where frequent winter measurements are made in connection with distribution of water at Old Town, deducting for Passadumkeag R. and intervening area.
10. E. Branch Penobscot R. at Grindstone, Me.	1902–13	B –	Rating curve well defined though velocities sluggish at low stages, and occasional log jams affect stage discharge relation. Discharge relation affected by ice 3 to 4 months each year, during which records are missing or are based on rough estimates. Gage usually read once daily (except Sunday) and three times a week in winter. Little effect from storage regulation.
	1914–20	A –	Two to four discharge measurements each winter and estimates during ice conditions based on gage heights corrected for backwater.
11. Mattawamkeag R. at Mattawamkeag, Me.	1902–13	B –	Rating curve well defined, though there is an occasional effect from log jams and possibly an occasional backwater effect from the Penobscot River. Discharge relation affected by ice 3 to 4 months each year, during which records are missing or are based on rough estimates. Gage read twice daily except in winter when it is read twice a week.
	1914–20	A –	Two to five discharge measurements each winter and estimates during ice conditions based on gage heights corrected for backwater.
12. Piscataquis R. near Foxcroft, Me.	1902–15	D	Low water rating curve only fairly well defined. Occasional log jams. Winter records either missing, rough estimates, or open water rating curve applied. Gage read twice a day. Several mills above that cause fluctuation in low water flow.
	1916–20	C +	Two or three discharge measurements each winter and estimates based on backwater effect.

RESULTS OF GRADING.

Station.	Period.	Grade.	Remarks.
PENOBSCOT RIVER BASIN — (Cont.).			
13. Passadumkeag R. at Lowell, Me......	1915–20	B –	Location of gage changed Oct. 1, 1917. Rating curves fairly well defined though discharge measuremets not very numerous. Ice three to four months each year during which estimates based on backwater effect determined by three to eight discharge measurements each winter.
14. Kenduskeag Stream near Bangor, Me...	1908–13	C+	Rating curve well defined, though control may shift slightly. Ice two to four months each year. Winter records either rough estimates or open water rating curve used. Two readings a day, three times a week in winter.
	1914–20	B+	One to four discharge measurements each winter and estimates based on backwater effect.
ST. GEORGE RIVER BASIN.			
15. St. George R. at Union, Me..........	1913–14	B	Rating curve fairly well defined, although a big shift in the control was indicated by discharge measurements in 1915. Records missing from Jan. 14 to March 2, 1914. Possibly some ice effect in December, 1914, but none assumed. Gage read once a day.
KENNEBEC RIVER BASIN.			
16. Moose R. near Rockwood, Me........	1902–08 1910–12	C –	Lower part of rating curve fairly well defined. Possibly backwater effect from Moosehead Lake. Winter records either missing or rough estimates. Gage read twice a day. During log driving season (say two months) a fluctuation of a foot or more likely each day.
17. Kennebec R. at The Forks, Me.......	1902–12	D+	Rating curve fairly well defined. Stage discharge relation affected by log jams and by backwater from Dead River. Records doubtful during log driving season (up to three months) on account of daily fluctuation and log jams. Winter records either missing or rough estimates.
	1913–20	B+	Automatic gage installed in 1912. Winter estimates based on gage heights corrected for backwater effect determined by one to three discharge measurements each winter. Gage relocated in 1919.
18. Kennebec R. at Bingham, Me........	1907–10	C –	Rating curve well defined, though only nine discharge measurements. Ice four to five months during which period records based entirely on estimates from other stations. For two months considerable daily fluctuation in stage on account of log driving. Ordinarily two readings a day.

19. Kennebec R. at North Anson, Me.....	1901–07	C–	Rating curve fairly well defined at medium and low stages—uncertain at high stages. Ice about four months. Winter records missing prior to 1904. From 1904 to 1906 winter records based on an ice rating curve, using gage heights to bottom of ice. Considerable daily fluctuation during log driving season (two to three months). Gage read twice a day.
20. Kennebec R. at Waterville, Me.......	1892–1920	B–	When flow is below 3 800 sec. ft., generally all measured by waterwheels rated at Holyoke under approximately same head. Some uncertainty regarding condition of flashboards.
21. Dead River at The Forks, Me........	1901–07 1910–14	B–	Rating curve well defined except below 400 sec. ft. Winter records missing or based on rough estimates. Log driving may have caused daily fluctuation during part of year. Gage read twice a day ordinarily; three times a week in winter.
	1915–20	B+	Winter estimates based on gage heights corrected for backwater determined by one to three discharge measurements each winter.
22. Sandy R. at Farmington, Me.........	1910–15	C+	Rating curve fairly well defined except no discharge measurements above 1520 sec. ft. Discharge relation seriously affected by ice for three to four months each winter and records based on estimates. Gage read once a day. Water power plant at Phillips may have caused some daily fluctuation.
ANDROSCOGGIN RIVER BASIN.			
23. Androscoggin R. at Errol Dam, N. H.	1905–20	B–	Flow measured by opening of sluice gates which have been rated approximately by current meter measurements. Low water flows check up fairly well with records at Berlin.
24. Androscoggin R. at Berlin, N. H......	1913–20	B	Flow up to 2200 sec. ft. measured by wheels rated from Holyoke tests. 24-hour power. Dam irregular in shape and not in good condition for weir measurements, but due to storage control flow does not usually exceed 2200 sec. ft. more than two to three months a year.
25. Androscoggin R. at Rumford Falls, Me.	1892–20	A	Flow computed from discharge over the dam by use of the Francis weir formula with modified coefficient, and the quantities passing through the various wheels of the power station and mills, which have been carefully rated.
26. Magalloway R. at Aziscohos Dam, Me.	1912–20	B–	Flow measured by the openings of two gates shaped very much like cylinder gates of water wheels. Approximately rated by means of current meter measurements.

Results of Grading.

Station.	Period.	Grade.	
Androscoggin River Basin — (Cont.).			
27. Little Androscoggin R. near S. Paris, Me.	1913–20	A−	Rating curve well defined below 700 sec. ft. Gage read to tenths once daily. Stage discharge relation not affected by ice.
Presumpscot River Basin.			
28. Presumpscot R. at outlet of Sebago Lake, Me.	1887–1903	B−	Flow determined from discharge of sluice gates and waste over dam.
	1904–1920	A	Discharge measured by water wheels with use of Allen turbine meter. Amount of flow over dam and through waste gates small. About 13 sec. ft. diverted for Portland Water Supply which is not included in published records.
Saco River Basin.			
29. Saco R. near Center Conway, N. H.	1903–12	D+	Rating curve only fairly well defined. Winter records missing.
30. Saco R. at Cornish, Me.	1916–18	B	Rating curve fairly well defined between 1,000 and 7,000 sec. ft. Winter records determined by correction of gage heights for backwater as determined by one to three discharge measurements each winter. Gage read twice a day. Fluctuation caused by power plant at Hiram.
	1919–20	A	Rating curve well defined. Automatic gage.
31. Saco R. at West Buxgon, Me.	....	..	Not rated.
32. Ossipee R. at Cornish, Me.	1916–20	B+	Rating curve well defined. Winter records affected by ice three to four months and estimates based on gage heights corrected for backwater as determined by one to three discharge measurements each winter. Gage read once a day. There may be some daily fluctuation due to operation of of power station at Keizar Falls.
Merrimack River Basin.			
33. Pemigewasset R. at Plymouth, N. H.	1903–18	C	Rating curve fairly well defined above 600 sec. ft, but has shifted widely below that point, and low water records much in doubt. Discharge relation affected by ice for two to three months and records based on rough estimates. Two readings a day except Sundays.
	1919–20	B+	Sufficient discharge measurements to define lower part of rating curve fairly well. Winter records based on correction of gage heights for backwater as determined by two discharge measurements each winter.

34. Merrimack R. at Franklin Jct., N. H. .	1903–15	D–	Several rating curves used, none well defined. Stage discharge relation affected by ice from one to three months each winter. Winter estimates based on records at other stations. Gage read twice daily except Sundays.
	1916–20	D+	Rating curve fairly well defined. First winter discharge measurements in 1918. Reliability of gage readings questionable prior to 1918.
35. Merrimack R. at Garvins Falls, N. H.	1904–16	C	Flow through wheels up to 2 700 sec. ft. determined from kilowatt output based on current meter measurements in 1904–05. Flow over dam and wasteways determined from Francis formula with modified coefficients. Mean daily flow taken as average of flow at 7.30 A.M., 12 M. and 5 P.M.
36. Merrimack R. at Lawrence, Mass.	1880–1920	A	Flow up to 9 000 to 9 500 sec. ft. measured by water wheels tested at Holyoke and checked by measurements in place. Mostly 8 to 9 hour power. For 9 months or more flow over dam determined by depth over flashboards which are kept in excellent condition and their height determined by levels. When flashboards are off flow computed by Francis Lawrence dam formula. When condition of flashboards is unknown, flow determined from rating curve for height of river below dam.
37. Smith R. near Bristol, N. H.	1918–20	B+	Rating curve fairly well defined up to 600 sec. ft. Discharge relation affected by ice from two to four months. Estimates during ice conditions based on backwater effect determined by two discharge measurements each winter. Gage read twice daily. Very little fluctuation caused by operations of small mills above gaging station.
38. Contoocook R. near Elmwood, N. H. . .	1918–20	B–	Rating curve only fairly well defined. Discharge relation seriously affected by ice from two to four months. Winter estimates based on backwater effect due to ice determined by two to three discharge measurements each winter. Gage read twice daily. Effect of pondage regulation uncertain.
39. Blackwater R. near Contoocook, N. H.	1918–20	A–	Rating curve well defined. Discharge relation affected very little by ice. Gage read twice daily. No daily fluctuation due to pondage. Some doubt as to absolute reliability of gage readings.
40. Suncook R. at North Chichester, N.H.	1918–20	B	Rating curve fairly well defined. Stage discharge relation affected by ice. Winter estimates based on corrections for backwater determined by one or two discharge measurements each winter. Large daily fluctuation. Operation of recording gage not very satisfactory.

RESULTS OF GRADING.

Station.	Period.	Grade.	Remarks.
MERRIMACK RIVER BASIN—(Cont.).			
41. Souhegan R. at Merrimack, N. H.....	1909–14	B	Rating curve well defined. Gage read twice a day. Some fluctuation caused by operation of mills at Milford. Stage discharge relation not much affected by ice except in severe winters.
	1915–20	A	Automatic gage since 1913.
42. South Branch Nashua R., at Clinton, Mass. (Wachusett)...............	1896–1920	A	1896–98. Flow measured at an unused dam in Clinton. Automatic gage. Planked measuring flume for rating dam by current meter measurements. 1898–1911. Flow measured at a weir constructed in aqueduct. Automatic gage and special section prepared for rating weir by current meter measurements. 1911–20. Flow measured by Venturi meters rated by current meters. Water wasted over flashboards determined from Francis weir formula, over masonry crest of overflow by coefficients determined from experiments at Cornell. Monthly flows only computed.
43. Concord R. at Lowell, Mass..........	1901–20	D	Flow up to 350 sec. ft. determined by wheel ratings based on Holyoke tests checked by current meter measurements in place. Flow over dam on which 8 in. to 10 in. of flashboards are carried computed from Francis formula. Daily flow taken as mean of forenoon and afternoon readings, but low flows seriously affected by the operation of pondage.
44. Sudbury R. near Framingham, Mass...	1875–97	A	Flow measured by weirs rated by current meter measurements.
	1898–1920	A–	Since 1898 water from Wachusett Reservoir has been discharged into Sudbury system, and Sudbury yield determined by process of subtraction. Since 1912 water drawn from Sudbury system into Weston Aqueduct has been measured by Venturi meters.
PAWTUXET RIVER BASIN.			
45. Pawtuxet R. at Fiskeville, R. I.......	1916–20	A	Station at unused dam of B. B. Knight & Co. Rating curve determined by experiments on model and later checked by current meter measurements. Automatic gage.
THAMES RIVER BASIN.			
46. Quinnebaug R. at Jewett City, Conn.	1918–20	A	Rating curve well defined. Little if any effect from ice. Operation of automatic gage satisfactory except for short periods.

CONNECTICUT RIVER BASIN. 47. Connecticut R. at First Lake near Pittsburgh, N. H.	1917–18	B+	During 1917 and part of 1918 discharge determined by openings of sluice gate rated by current meter measurements. Rating fairly good. Sluice gate ratings affected by ice.
	1919–1920	A	Since July, 1918, records obtained at open channel gaging station. Rating curve well defined. Not affected by ice. Operation of automatic gage satisfactory.
48. Connecticut R. at Orford, N. H.	1900–1914	B+	Rating curve well defined, though small shifts in rating curve frequent. Stage discharge relation affected by ice about three months a year on an average. Winter discharge measurements each year since 1903 except in 1911, and winter estimates probably better than at most stations during this period.
	1915–1920	A–	Flashboards at Wilder dam raised in 1915, and different rating curves required for different heights of flashboards. These rating curves fairly well defined, and condition of flashboards fairly well known during greater part of the year. Winter flows determined from gage heights corrected for backwater effect of ice determined by 3 to 6 discharge measurements each winter.
49. Connecticut R. at Sunderland, Mass.	1904–1906	B–	Rating curve well defined above 7 000 sec. ft., not very well defined below. Stage discharge relation affected by ice two to three months, during which period estimates are approximate.
	1907–1914	B+	Rating curve well defined. One to three winter discharge measurements usually available for winter estimates.
	1915–1920	A	Automatic gage since 1916. Several discharge measurements each winter and flows computed from gage heights corrected for backwater due to ice.
50. Connecticut R. at Holyoke, Mass.	1880–1899	B	Flow up to about 8,000 sec. ft. determined by water wheel ratings based on Holyoke tests. Coefficients for computing waste over dam uncertain.
51. Passumpsic R. at Pierce's Mills, near St. Johnsbury, Vt.	1909–15	B–	Rating curve only fairly well defined. Stage discharge relation affected by ice two to four months. Winter records missing or based on rough estimates. Two gage readings a day. Some fluctuation in stage due to operation of mills.
	1916–20	B	Winter records based on gage heights corrected for backwater determined by discharge measurements.

Results of Grading.

Station.	Period.	Grade.	Remarks.
CONNECTICUT RIVER BASIN — (Cont.).			
52. White R. at West Hartford, Vt.	1915–20	A –	Rating curve well defined. Ice one to three months. Winter records based on gage heights corrected for backwater determined by discharge measurements. Gage read twice a day. Flow probably affected somewhat by operation of mills at Sharon.
53. Ashuelot R. at Hinsdale, N. H.	1907–09	B	Rating curve well defined. Winter discharge based on climatological data and approximate rating curves. Two gage readings a day. Possibly some daily fluctuation.
	1914–20	A –	Winter records based on gage heights corrected for backwater determined by discharge measurements.
54. Millers R. near Winchendon, Mass.	1916–20	B –	Control shifting and rating curves only fairly well defined. Two to four discharge measurements each winter, but on account of large daily fluctuation, water frequently overflows the ice, causing variable backwater effect.
55. Millers R. at Erving, Mass.	1914–1915	B	Rating curve well defined, though not many discharge measurements below 200 sec. ft. Ice one to three months. Variable backwater effect of ice caused by fluctuation in stage due to power plant operation. Gage read twice daily, and results corrected by coefficient determined after installation of automatic gage.
	1916–20	A—	Automatic gage.
56. Sip Pond Brook near Winchendon, Mass.	1916–17	B	Rating curve only fairly well defined. Automatic gage except for June, 1916 and Dec. 13, 1916 to June 26, 1917. Considerable daily fluctuation. Stage discharge relation affected by ice about two months, and estimates based on gage heights corrected for backwater effect determined by discharge measurements.
	1918–20	A –	Rating curve well defined except below 20 sec. ft. when it is fairly well defined. Automatic gage.
57. Priest Brook near Winchendon, Mass.	1916–20	A –	Rating curve well defined. Stage discharge relation not much affected by ice in open winters; affected two months or so in severe winters. Gage read twice daily.

58. East Branch Tully R. near Athol, Mass.	1916–20	A	Rating curve extremely well defined. Stage discharge relation slightly affected by ice for short periods. Gage read twice a day. No pondage regulation.
59. Moss Brook at Wendell Depot, Mass.	1916–20	A	Rating curve well defined. Stage discharge slightly affected by ice from one to three months. Gage read twice daily. No pondage regulation.
60. Deerfield R. at Charlemont, Mass.	1913–1920	A	Rating curve extremely well defined. Automatic gage. Stage discharge relation affected by ice two to three months. Numerous winter discharge measurements and power station records at Shelburne Falls available for comparison.
61. Deerfield R. at Shelburne Falls, Mass.	1907–13	A	(At power station of Greenfield El. Lt. Co.) Discharge determined by water wheels rated in place with current meters. Gate openings and head read hourly. One foot of flashboards on dam. Boards were kept in good condition.
	1914–15	B+	(At No. 2 power station of New England Power Co.) Discharge determined from power output. Wheel ratings from Holyoke test. Flashboards kept in good condition except in times of high water.
62. Ware R. at Gibbs Crossing, Mass.	1912–20	A–	Rating curve well defined. Stage discharge relation seriously affected by ice from one to three months. Fluctuating stage causes variable back water effect under ice conditions.
63. Swift R. at West Ware, Mass.	1912–20	B+	Rating curve fairly well defined. Stage discharge relation affected by ice one to three months each winter. Flow computed from gage heights corrected for backwater effect determined by discharge measurements.
64. Quaboag R. at West Brimfield, Mass.	1912–20	A–	Rating curve well defined, although there has been a slight shift in control. Stage discharge relation affected by ice from one to three months. The diurnal fluctuation breaks up the ice and causes a variable backwater effect.
65. Westfield R. at Knightville, Mass.	1909–15	B–	Rating curve fairly well defined, although not many measurements between 60 and 240 sec. ft. Stage discharge relation affected by ice from one to three months. Winter records based almost entirely on climatological data and comparison with other streams. Gage read twice daily. No pondage regulation.
	1916–20	B	Winter estimates based on gage heights corrected for backwater determined by two to four discharge measurements each winter.

Results of Grading.

Station.	Period.	Grade.	Remarks.
Connecticut River Basin — (Cont.).			
66. Westfield. R near Westfield, Mass.....	1914–20	A	Rating curve well defined except for lower part of curve used in 1914 and 1915. Stage discharge relation usually affected by ice for less than a month. Discharge measurements each winter. Automatic gage.
67. Middle Branch of Westfield R. at Goss Heights, Mass..................	1910–15	B –	Control shifting and rating curves only fairly well defined. Discharge relation affected by ice from one to four months. Discharge measurements each winter. Gage read twice daily prior to 1912. Automatic gage since 1912.
	1916–20	B	Winter records based on gage heights corrected for backwater effect. Automatic gage not working properly at times and records based on comparison with Knightville.
68. Westfield Little R. near Westfield, Mass..........................	1905–09	A –	Rating curve well defined. Stage discharge relation affected by ice one to two months. During 1906–07, winter flows determined from weir located a short distance downstream. Several winter discharge measurements in 1909.
	1910–20	A	Flow diverted for Springfield water supply measured by Venturi meter. Low water flow not diverted (below 163 second feet) measured by sharp crested weir 12 ft. long. Flow above 163 sec. ft. determined by head on concrete dam 155. 4 ft. long. Automatic gage.
69. Farmington R. near New Boston, Mass.	1913–20	A –	Rating curve well defined. Stage discharge relation seriously affected by ice, with ice jams occasionally forming. Winter discharge measurements each year except 1916. Automatic gage.
70. Hockanum R. near East Hartford, Conn.	1919–20	A	Rating curve rather well defined. Discharge relation not affected by ice. Operation of automatic gage satisfactory.
Housatonic River Basin.			
71. Housatonic R. at Great Barrington, Mass.	1913–20	B	Rating curve well defined. Stage discharge relation not much affected by ice. Gage read twice daily. Some daily fluctuation on account of operation of mills above.

72. Housatonic R. at Falls Village, Conn..	1912–14	B+	Rating curve well defined. Stage discharge relation affected by ice, but records of power output at power station just above gaging station and height of water on dam available. Gage read twice daily before power plant was placed in operation.
	1915–20	A	Automatic Gage.
73. Pomperaug R. at Bennett's Bridge, Conn.	1913–16	C+	Rating curve not very well defined. Discharge records affected by ice from two to three months each winter. Records missing or no estimates made during winter for 49 days in 1913–14 and 79 days in 1914–15. Gage read twice daily except in winter when once a day. Power plant above causes small daily fluctuation in low water.
St. Lawrence River Basin.			
74. Otter Creek at Middlebury, Vt.	1903–07	D+	Rating not very well defined. Winter records missing for three to four months. Gage read twice daily. Probable not much daily fluctuation from use of pondage.
	1910–15	C+	Rating curve defined somewhat better than in previous period. Winter estimates based on gage heights, observers notes and weather records.
	1916–20	B	Rating curve fairly well defined. Winter records based on gage heights corrected for backwater determinated by discharge measurements beginning in 1916–17.
75. Winooski R. at Montpelier, Vt.	1914–20	A	Rating curve well defined. Winter records based on gage heights corrected for backwater determined by three to four discharge measurements each winter. Automatic gage.
76. Winooski R. at Richmond, Vt.	1903–07 & 1910	D	Rating curve not very well defined. Winter records missing for about 3½ months each year. Gage read twice daily. Daily flow aff[illegible] at low stages by operation of pondage.
77. Dog. R. at Northfield, Vt.	1909–14	C	Rating curve only fairly well defined. Winter records missing or based on climatological data. Gage read twice daily. Some fluctuation in stage on account of operation of pondage.
	1915–20	B−	Automatic gage. Winter records missing in 1917 and 1918.
78. Lamoille R. at Cady Falls, Vt.	1913–20	A−	Rating curve extremely well defined. Winter records based on gage heights corrected for backwater determined by discharge measurements. Occasionally trouble with operation of automatic gage.

RESULTS OF GRADING.

Station.	Period.	Grade.	Remarks.
ST. LAWRENCE RIVER BASIN—(Cont.).			
79. Lamoille R. at Johnson, Vt..........	1910–13	D	Rating curve not very well defined. Winter records missing. Gage read twice daily.
80. Green R. at Garfield, Vt.............	1915–20	A	Sharp crested weir with rating curve determined by Francis weir formula with correction determined by current meter measurements. Weir flooded out when flow exceeds 130 sec. ft. and results somewhat uncertain. Stage discharge relation not affected by ice. Gage read twice daily. No pondage regulation.
81. Missiquoi R. near Richford, Vt.......	1909–15	D–	Rating curve fairly well defined. Winter records missing. Gage read twice daily. Considerable daily fluctuation on account of operation of pondage.
	1916–20	B+	Winter records based on gage heights corrected for backwater determined by several current meter measurements each winter.
82. Clyde R. at West Derby, Vt..........	1909–15	C–	Rating curve not well defined. Winter records missing or based on climatological data. Gage read twice daily.
	1916–20	B–	Winter records based on gage heights corrected for backwater determined by one to three current meter measurements each winter. Automatic gage.

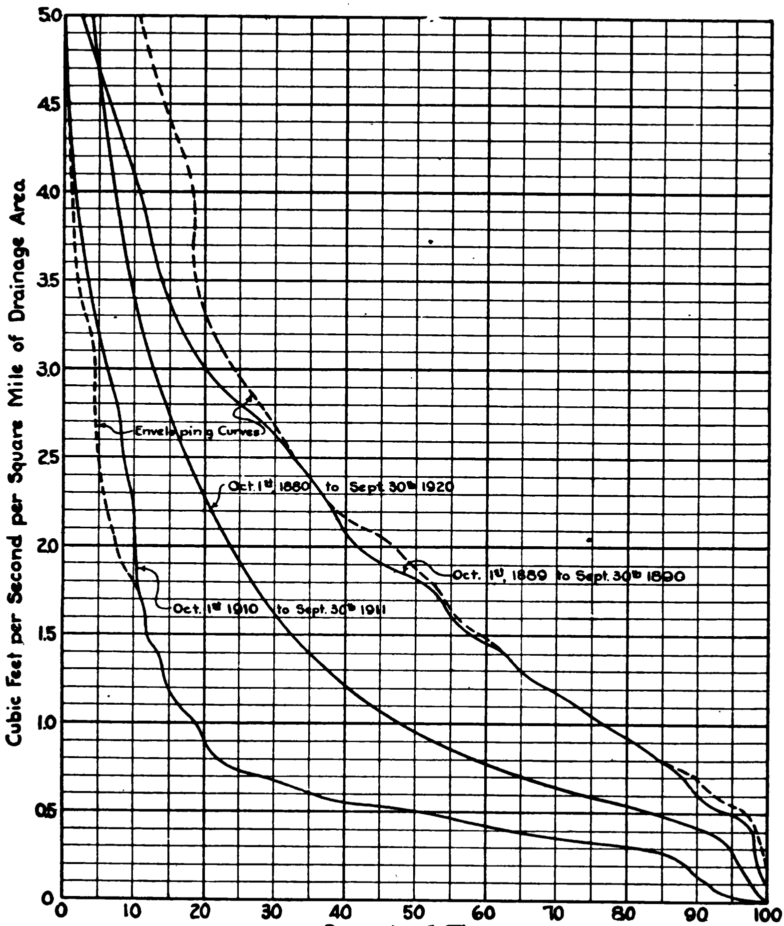

FIG. 7. — DURATION CURVES

Forty-Year Average, Enveloping Curves, and Maximum and Minimum years.

Merrimack River at Lawrence, Mass.

Net drainage area before March 6, 1898, 4 570 sq. mi.

Net drainage area since March 6, 1898, 4 452 sq. mi.

Based on climatic year, October 1, to September 30.

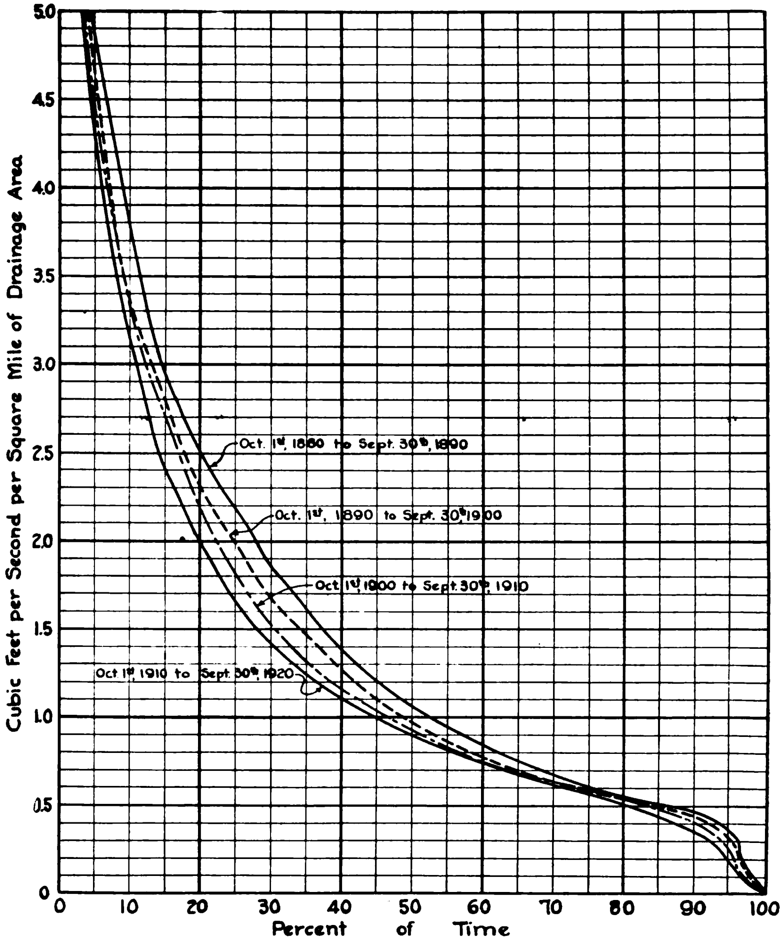

FIG. 8. — DURATION CURVES

Comparison of Ten-Year Periods Merrimack River at Lawrence, Mass.
Net drainage area before March 6, 1898, 4 570 sq. mi.
Net drainage area since March 6, 1898, 4 452 sq. mi.
Based on climatic year, October 1 to September 30.

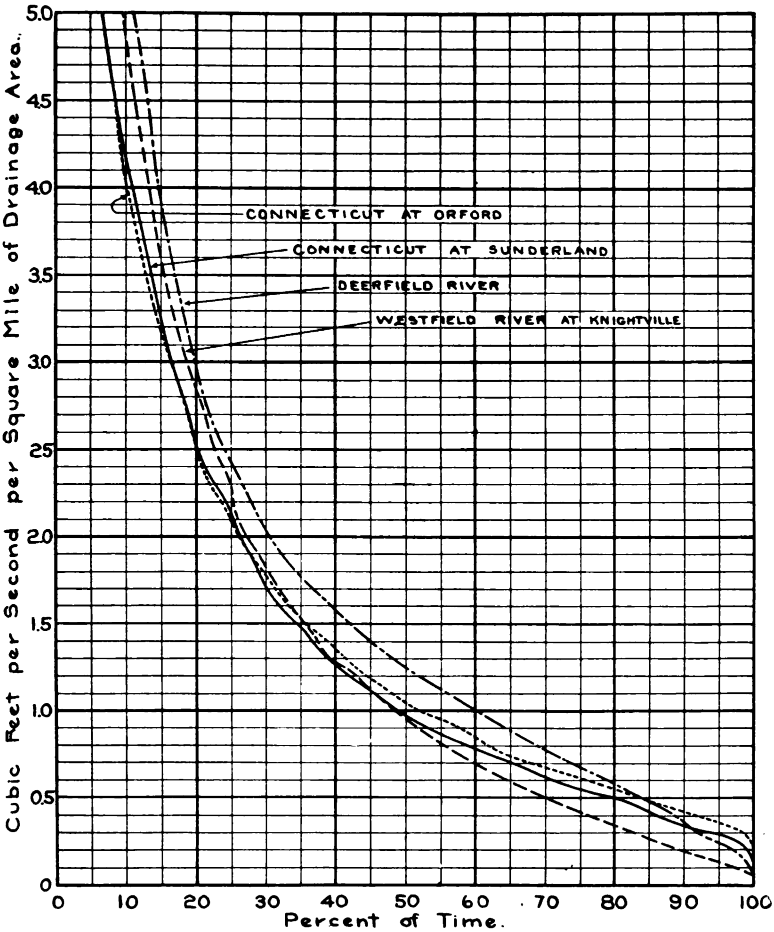

FIG. 9. — DURATION CURVES

Ten-Year Period 1911-1920
Connecticut River at Orford (3 100 sq. mi.)
Connecticut River at Sunderland (8 000 sq. mi.)
Deerfield River at Shelburne Falls (501 sq. mi.) and Charlemont (362 sq. mi.)
Westfield River at Knightville (162 sq. mi.)
Based on climatic year October 1 to September 30.

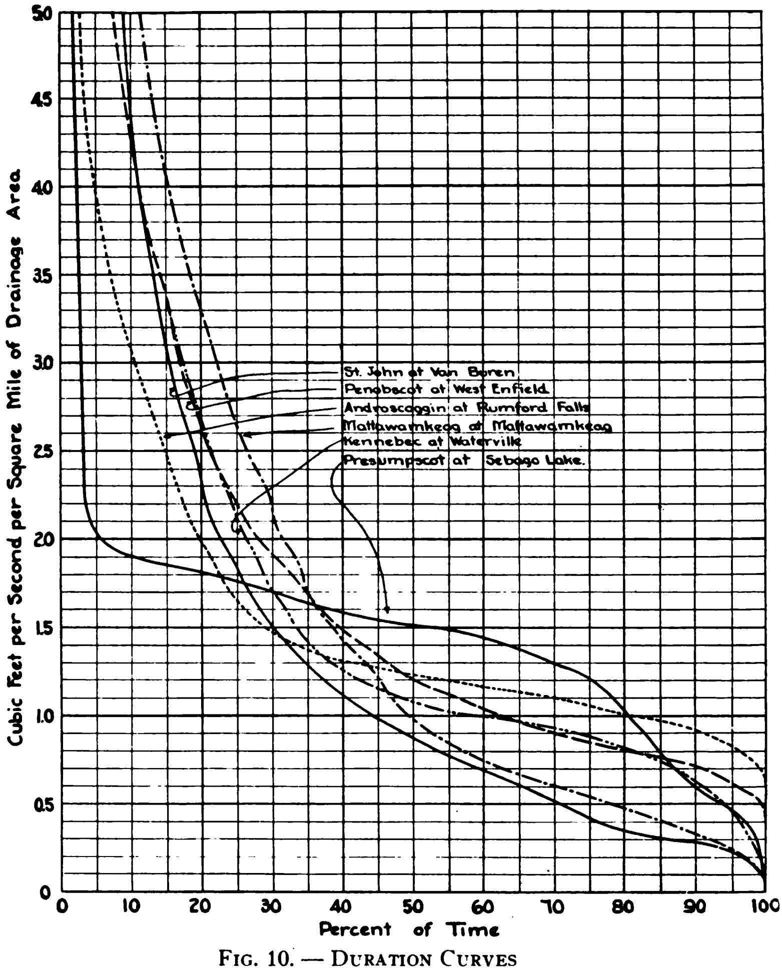

FIG. 10. — DURATION CURVES
Eight-Year Period, 1913-1920

St. John River at Van Buren (8 270 sq. mi.)
Penobscot River at West Enfield (6 600 sq. mi.)
Androscoggin River at Rumford Falls (2 090 sq. mi.)
Mattawamkeag River at Mattawamkeag –(1 500 sq. mi.) (7 years)
Kennebec River at Waterville (4 270 sq. mi.)
Presumpscot River at Sebago Lake (436 sq. mi.)
Based on climatic year, October 1 to September 30.

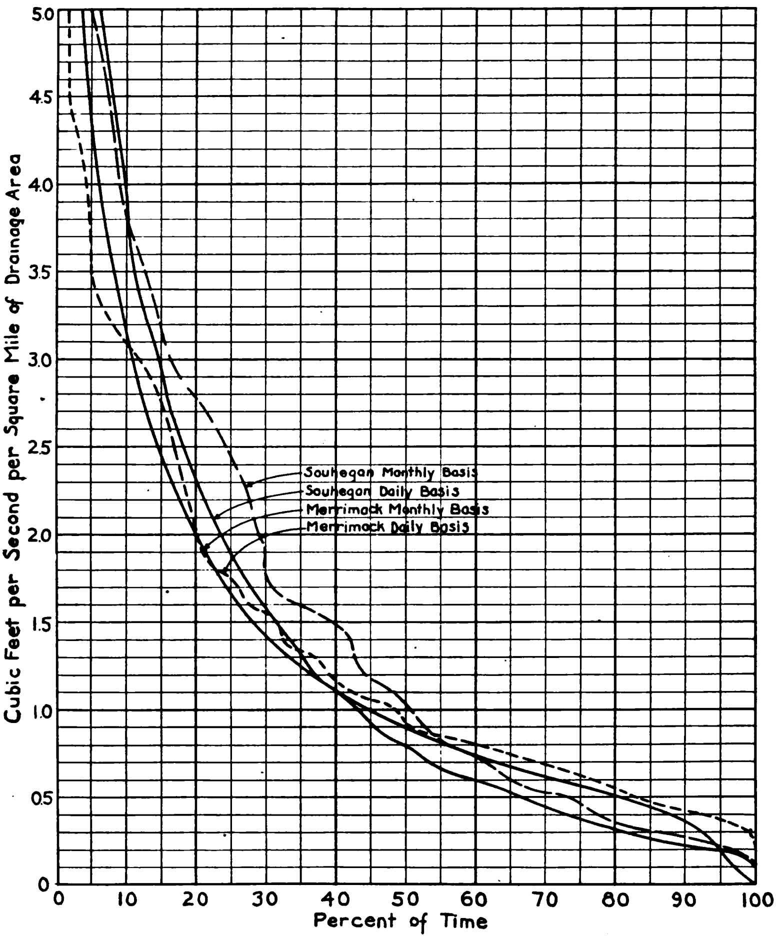

FIG. 11. — DURATION CURVES

Comparsion of Daily and Monthly Basis Ten Year period 1911-1920.

Merrimack River at Lawrence, Mass. (4 452 sq. mi. net.)

Souhegan River at Merrimack, N. H. (168 sq. mi.)

Based on climatic year, October 1 to September 30.

MEAN ANNUAL PRECIPITATION.

In Inches.

(For years 1901-1920 inclusive except where otherwise noted).

Location.	Elevation.	Precipitation	
Maine			
Eastport	53	36.59	
Houlton	362	27.90	(1903-19)
Orono	129	39.67	
Millinocket	386	42.43	
Van Buren	510	34.98	(1903-08: 1913-18)
Greenville	1 140	43.47	(1906-20)
Winslow	90	37.12	
Farmington	450	42.09	
Lewiston	185	42.21	
Portland	99	40.79	
Rumford Falls	505	39.15	
Cornish	778	46.43	
New Hampshire			
Errol Dam	1 260	36.42	(1885-1907)
Mt. Washington	6 293	83.53	(1872-1886)
Bethlehem	1 470	37.19	
Hanover	603	34.76	
Lakeport	500	40.34	
Concord	350	36.07	
Manchester	200	39.40	
Keene	506	37.07	
Vermont			
Enosburg Falls	601	39.10	
Burlington	404	31.40	
St. Johnsbury	711	35.48	
Northfield	876	32.40	
Woodstock	700	37.45	(omitting 1914)
Wells	750	36.66	(1901-18)
Somerset	2 096	52.13	(1912-20)
Massachusetts			
Lawrence	51	39.05	
Chestnut Hill	124	44.68	
Milton (Blue Hill)	640	45.59	
Clinton	370	45.11	
Princeton	1 125	42.82	
Amherst	222	42.65	
Holyoke	90	44.60	
Williamstown	711	37.17	
Pittsfield	1 050	40.31	
Rhode Island			
Providence	160	41.95	
Kingston	250	50.46	
Connecticut			
Hartford	159	44.23	
New London	47	42.28	
New Haven	127	45.16	
Cornwall	1 300	47.57	

GAGING STATIONS.

Stream.

ST. JOHN RIVER BASIN.

1. St. John R. at Fort Kent, Me.
2. St. John R. at Van Buren, Me.
3. Aroostook R. at Fort Fairfield, Me.

ST. CROIX RIVER BASIN.

4. St. Croix R. near Woodland, Me.

MACHIAS RIVER BASIN.

5. Machias R. at Whitneyville, Me.

UNION RIVER BASIN.

6. West Branch of Union R. at Amherst, Me.

PENOBSCOT RIVER BASIN.

7. West Branch of Penobscot R. at Millinocket, Me.
8. West Branch of Penobscot R. near Medway, Me.
9. Penobscot R. at West Enfield, Me.
10. East Branch of Penobscot R. at Grindstone, Me.
11. Mattawamkeag R. at Mattawamkeag, Me.
12. Piscataquis R. near Foxcroft, Me.
13. Passadumkeag R. at Lowell, Me.
14. Kenduskeag Stream near Bangor, Me.

ST. GEORGE RIVER BASIN.

15. St. George R. at Union, Me.

KENNEBEC RIVER BASIN.

16. Moose R. near Rockwood, Me.
17. Kennebec R. at The Forks, Me.
18. Kennebec R. at Bingham, Me.
19. Kennebec R. at North Anson, Me.
20. Kennebec R. at Waterville, Me.
21. Dead R. at The Forks, Me.
22. Sandy R. at Framington, Me.

ANDROSCOGGIN RIVER BASIN.

23. Androscoggin R., at Errol Dam, N.H.
24. Androscoggin R. at Berlin, N. H.
25. Androscoggin R. at Rumford Falls, Me.
26. Magalloway R. at Aziscohos Dam, Me.
27. Little Androscoggin R. near S. Paris, Me.

PRESUMPSCOT RIVER BASIN.

28. Presumpscot R. at outlet of Sebago Lake, Me.

SACO RIVER BASIN.

29. Saco R. near Center Conway, N. H.
30. Saco R. at Cornish, Me.
31. Saco R. at West Buxton, Me.
32. Ossipee R. at Cornish, Me.

MERRIMACK RIVER BASIN.

33. Pemigewasset R. at Plymouth, N. H.
34. Merrimack R. at Franklin Jct., N. H.
35. Merrimack R. at Garvins Falls, N. H.
36. Merrimack R. at Lawrence, Mass.
37. Smith R. near Bristol, N. H.
38. Contoocook R. near Elmwood, N. H.
38. Blackwater R. near Contoocook, N. H.
40. Suncook R. at North Chichester, N. H.
41. Souhegan R. at Merrimack, N. H.
42. South Branch Nashua R. at Clinton, Mass.
43. Concord R. at Lowell, Mass.
44. Sudbury R. near Framingham, Mass.

PAWTUXET RIVER BASIN.

45. Pawtuxet R. at Fiskeville, R. I.

THAMES RIVER BASIN.

46. Quinnebaug R. at Jewett City, Conn.

CONNECTICUT RIVER BASIN.

47. Connecticut R. at First Lake near Pittsburg, N. H.
48. Connecticut R. at Orford, N. H.
49. Connecticut R. at Sunderland, Mass.
50. Connecticut R. at Holyoke, Mass.
51. Passumpsic R. at Pierce's Mills, Vt.
52. White R. at West Hartford, Vt.
53. Ashuelot R. at Hinsdale, N. H.
54. Millers R. near Winchendon, Mass.
55. Millers R. at Erving, Mass.
56. Sip Pond Brook near Winchendon, Mass.
57. Priest Brook near Winchendon, Mass.
58. East Branch Tully R. near Athol, Mass.
59. Moss Brook at Wendell Depot, Mass.
60. Deerfield R. at Charlemont, Mass.
61. Deerfield R. at Shelburne Falls, Mass.
62. Ware R. at Gibbs Crossing, Mass.
63. Swift R. at West Ware, Mass.
64. Quaboag R. at West Brimfield, Mass.
65. Westfield R. at Knightville, Mass.
66. Westfield R. near Westfield, Mass.
67. Middle Branch of Westfield R. at Goss Heights, Mass.
68. Westfield Little R. near Westfield, Mass.
69. Farmington R. near New Boston, Mass.
70. Hockanum R. near East Hartford, Conn.

HOUSATONIC RIVER BASIN.

71. Housatonic R. at Great Barrington, Mass.
72. Housatonic R. at Falls Village, Conn.
73. Pomperaug R. at Bennetts Bridge, Conn.

ST. LAWRENCE RIVER BASIN.

74. Otter Creek at Middlebury, Vt.
75. Winooski R. at Montpelier, Vt.
76. Winooski R. at Richmond, Vt.
77. Dog R. at Northfield, Vt.
78. Lamoille R. at Cadys Falls, Vt.
79. Lamoille R. at Johnson, Vt.
80. Green R. at Garfield, Vt.
81. Missiquoi R. near Richford, Vt.
82. Clyde R. at West Derby, Vt.

Vol. IX NOVEMBER, 1922 No. 9

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

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CONSTRUCTION OF A PRE-CAST CONCRETE SLAB BRIDGE AT CENTRAL STREET, LOWELL.

By S. Stanley Kent,* Member Boston Society of Civil Engineers.

(Presented October 18, 1922.)

In so far as we know, there is but one water power company in this state that is responsible for the maintenance of bridges on the public highways. It is the great misfortune of the Proprietors of the Locks and Canals on the Merrimac River at Lowell to be that one company. The charter which was granted the Proprietors by the General Court in 1792, for the purpose of promoting navigation, placed certain obligations for the maintenance of bridges over the Pawtucket Canal on the navigation company. About 1821, the rights of the Proprietors of the Locks and Canals were purchased by the Merrimac Manufacturing Company, additional canals were dug, other manufacturing companies were interested to take part in the enterprise, and the development of water power used mostly for textile manufacturing became a more and more important use of the system, while with the coming of the railroads the use for navigation gradually died out. But the bridges are still with us.

Among them is the Central Street bridge over the Lower Pawtucket Canal. At this point the canal is about 80 ft. wide with a pier in the center which divides the Canal into two skew spans each from 40 to 45 ft. in length measured in the direction of

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the roadway. The average width of the street is about 65 ft., nearly 28 ft. of which is taken up by the two sidewalks. Of the 37 ft. between the curbs, the central 15 ft. or so are occupied by two car tracks. The first bridge over the canal at this point was built sometime between 1792 and 1796, at which latter date the canal was opened. The bridge was rebuilt in 1836, again in 1850 and still again in 1883. It was the bridge built in 1883 that was replaced this last summer. That bridge was built of queen post trussed stringers spaced about three feet on centers. Each truss consisted of two 7-in. x 14-in. stringers with a $1\frac{1}{2}$ in. diameter wrought iron truss rod in between. The construction was described as follows by Mr. James B. Francis, under whose direction the bridge was built.

"The stringers are of southern pine, the under planking $2\frac{1}{2}$-in. spruce, planed to a thickness of $2\frac{3}{8}$-in., matched and jointed and laid as tight as practicable, and strongly spiked to the stringers covered with coal tar of the kind used for concrete sidewalks put on hot and while soft, the top plank of 3-in Canada Pine jointed but not planed was put on and spiked to the plank under it, the spikes not going through.

"The surface of the roadway and sidewalks is of coal tar concrete $3\frac{1}{2}$-in. thick put on hot, costing $1.00 per sq. yd. The part of the same between the rails of the Horse Railroad track was paid for by the Horse Railroad Company.

"The work was all done without interrupting the ordinary travel or the use of the Horse Railroad. The pier with the exception of the capping was completed before the roadway or sidewalks were disturbed.

"The roadway was divided into three divisions, the middle division including the Horse Railroad, was first taken up and rebuilt, the Railroad having been first moved to the westerly side and the ordinary travel provided for on both the side divisions. When the middle division was completed, the ordinary travel was provided for on it and the westerly side division, and the other side division were taken up and rebuilt. When this was completed the remaining division was taken up and rebuilt."

It will thus be seen that a precedent was established for the reconstruction of the bridge without undue inconvenience to the public.

The construction of the 1883 bridge was begun on July 22, and completed on October 12. In 1900 the trussed stringers under the street railway tacks were replaced, and in 1907 strengthened again. In 1912 they were replaced by four steel girders which were not disturbed during the reconstruction of the bridge last summer. Outside of the section occupied by the Street Railway tracks, the bridge had required no repairs since 1883 excepting for the wearing surface, which in recent years had required extensive patching almost annually. When taken out the main timbers were found perfectly sound, as was also most of the planking outside of those parts near the Street Railway section and the curbs. The cause of renewing the bridge was the poor condition of the wearing surface and the excessive vibration of the entire bridge due to modern heavy loads.

The density of traffic on Central Street made the reconstruction of the bridge something of a problem. The bridge is within two and a half blocks of Merrimac Square which is the traffic center of Lowell, and it is hardly an exaggeration to say that virtually one half of the City of Lowell is reached by way of Central Street. There is no parallel street in the near vicinity over which traffic could be diverted. Electric cars pass over the Central Street bridge at the average rate of seventy per hour from five thirty in the morning until eleven thirty at night. To close even one half of the bridge for any length of time would cause serious inconvenience to the public.

The situation was further complicated by the fact that there have been business blocks put up over the canal on both sides of the bridge, with five store entrances to be kept open on the upstream side of the bridge and six entrances including the Strand Theatre, on the downstream side. The Strand is Lowell's largest moving picture theatre. The platforms over the canal on which these buildings are located are owned and leased by the Locks and Canals, and although the leases contain clauses reserving the right to rebuild the bridge, yet a moral if not legal obligation was felt to cause the minimum of inconvenience.

The situation was somewhat complicated from the structural side by the pipes and conduits which cross over the canal under the bridge. On the upstream side is a 16-in. city water main and a 12-in. gas pipe, both supported by independent trusses, and also a conduit containing a cable supplying a series current to the "White Way" lights, with one of the lamp posts located on the bridge. This conduit was hung from the bridge, as are also a nest of electric light conduits and a group of telephone cables which cross the canal on the downstream side.

Furthermore it is a skew bridge in the superlative degree. The lines of the abutments and the center pier all form angles with each other, and the same is true of the building lines and the curbs. There is no such thing as a right angle in the bridge.

It will thus be seen that the conditions called for a type of bridge which could be erected in the minimum of time and could be thrown open to traffic as soon as completed. Pre-cast concrete slabs were suggested by Mr. W. H. Durfee and seemed to meet these requirements best, and bids on this type of construction were called for by Mr. Arthur T. Safford, Chief Engineer of the Locks and Canals.

The design submitted by the New England Structural Company made under the direction of their Chief Engineer, Mr. E. N. Pike, was accepted. The plan as finally carried out was as follows:

Three 30-in. Bethlehem I-beams support the roadway on each side of the street railway tracks, with a 28-in. and a 26-in. Bethlehem beam under each sidewalk. The roadway girders are braced at eleven foot intervals with 10-in. I-beams, the tops of which are set flush with the tops of the main girders and with them form a quadrilateral of steel to support the pre-cast slabs. The slabs were designed to average about 11 ft. in length by 5 to 6 ft. in width and 7 in. to 12 in. in thickness This gave a weight of from 4 to 5 tons for each slab. The bridge is on a slight grade. This and also the crown of the bridge were taken care of by setting the tops of the I-beams horizontal and varying the thickness of the slabs. The slabs were designed for the standard 20-ton truck as specified by the State Department of Public Works. Five-eighths-inch round reinforcing rods were used

in both directions with every alternate rod bent up at the ends. The edges of the slabs were recessed a half inch for a width of 5-in. to 10-in., so as to let them fit down into the steel work. Kreolite wood blocks were laid on top of the slabs to form the wearing surface. It was at one time suggested that perhaps the tops of the slabs themselves could be used as the roadway surface, but the idea was abandoned for fear that the slabs would chip on the edges and that patching would prove difficult. The wood blocks were preferred to granite partly because of their lightness and smoothness, but more especially on account of the greater time required before the granite blocks could be thrown open to traffic. The pre-cast slabs were made for all of the roadway outside of the street railway area and for one half of each sidewalk. The outer half of the sidewalks next to the building lines was poured in place. Base plates to carry the main girders were set in the abutments and the center pier previous to the reconstruction. It was proposed to rebuild one half of the bridge between Saturday night and Monday morning, excepting for that half of the sidewalk to be poured in place, and repeating with the other half of the bridge on the following week end.

Under an arrangment satisfactory to the Proprietors of the Locks and Canals, the R. E. Runnels Construction Company of Lowell took the general contract for the reconstruction of the bridge in accordance with the design of the New England Structural Company, with the New England Structural Company furnishing and erecting the steel work, and the Locks and Canals setting the base plates and doing other preliminary work.

The base plates were set during the months of May and June of this year. Some little work was involved, as pockets had to be cut in the masonry abutments, many of which unavoidably came directly under the ends of the old trusses and necessitated shoring up from the bottom of the canal. In addition to this the Locks and Canals faced up the south abutment with concrete and carried the foundation down to hard pan. The original south abutment consisted of a rough stone wall laid dry and was founded on 3 to 4 ft., of black muck underlaid with hard pan. About a third of the abutment rested on short piles driven through the muck. The concrete, put

on averaged about a foot in thickness, with a sloping footing four to five wide which reached back under the old wall. This work was done in sections on three successive Sundays with the water drawn out of the canals.

The pre-cast slabs were made by the R. E. Runnels Company in their yard on Thorndike Street about three quarters of a mile from the bridge.

1: 2: 4: concrete was used. Each slab had four "U" shaped hooks made of ⅞-in. reinforcing steel cast into it for handling. These hooks were burned off after the slabs were finally placed. Steel curb edgings were cast in the sidewalk slabs to form the curb. After curing for about twenty days the slabs were all raised and their dimensions carefully checked and any irregularities corrected.

With all preparations completed, the week ends of July 16 and July 23 were set for the reconstruction of the bridge. During the days preceeding these dates the street railway tracks including both rails and ties and the planking and pavement between the rails were all renewed. Both in and outbound cars used the easterly track during the week of July 10 to 15, when the westerly track was relaid, and the situation was reversed the following week. During these periods both side of the bridge between the tracks and the curbs remained open to traffic.

Eleven o'clock Saturday night, July 15, was set as the zero hour for the replacement of the westerly half of the bridge. At that hour the street was entirely closed with the exception of the easterly sidewalk, the New England Structural Company began the erection of their derrick, and the Runnels Construction Company started in tearing up the tar concrete wearing surface. It was hard and tough and thick. Two or three hours work with hammers and wedges made little impression, but yet enough to open up the way for their trump card. This was an Erie steam shovel which came lumbering onto the scene in the early evening, spitting water and steam like an angry dragon. Holes were cut through the bridge planking after wedging off the tar concrete and through these holes a husky chain was passed and made fast to the bucket of the steam shovel. The steam

shovel then sat back on its haunches and reared and tore and snorted and snarled. "The 3-in. Canada pine, jointed but not planed" which Mr. Francis had laid "on the under planking of $2\frac{1}{2}$-in. spruce planed to a thickness of $2\frac{3}{8}$-in. matched and jointed and laid as tight as practicable and strongly spiked to the

Fig. 1. — Central Street Bridge, West Side, July 16, 1922.

stringers" came up reluctantly, but it came nevertheless. The use of the steam shovel reduced this operation which might well have taken a day or two if done by hand to a matter of hours. The steam shovel was also used later for placing the slabs. By eight o'clock on Sunday morning that half of the deck over the southerly span was removed so that the New England Structural Company was able to start lifting out the old trusses and putting in the new I-beams. The work was carried on continuously through Sunday and Sunday night with the traffic still shut off. When Monday morning came the roadway slabs were all in

place and part of the sidewalk slabs. It was then necessary to suspend operations until Monday night in order to open up the easterly half of the bridge for traffic and to place short wooden bridges into the store entrances. The remaining sidewalk slabs were placed in position Monday night, and the kreolite blocks

FIG. 2. — PLACING CONCRETE SLAB, CENTRAL STREET BRIDGE, EAST SIDE, JULY 23, 1922.

laid. The roadway and one half of the sidewalk was all completed and opened up at 11 o'clock Tuesday morning. The actual working time required for replacing this half of the bridge was something under sixty hours.

The electric cars were diverted to the rebuilt westerly track on Monday morning and during the week the easterly track was replaced and new pavement laid. During this period with the exception of Monday, both sides of the roadway and the westerly track were again open for traffic. One way traffic only was permitted on Monday.

The work was repeated in a similar way with the easterly half of the bridge the following week end. Due to the experience gained on the first half of the bridge, the work progressed more rapidly. The old deck was entirely removed by 6 A.M. Sunday morning, the old trusses all lifted out by 11 A.M., and the new

FIG. 3 — CENTRAL STREET BRIDGE AS COMPLETED, JULY 31, 1922.

steel work placed and riveted by 7 o'clock Sunday evening. The placing of the slabs began at 4 o'clock Sunday afternoon and was completed by midnight Sunday night. This was two hours in advance of a schedule which called for opening the entire bridge for traffic at 8 o'clock Monday morning. But the heavens intervened. A steady rain Sunday afternoon and night of course made it impossible to lay the wood blocks in pitch. It was the middle of the week before the pavement could be laid, although with both the railway tracks and the westerly half of the bridge already completed the traffic could go in both direc-

tions. The remaining half of both sidewalks were poured in place during this week.

Great credit is due the R. E. Runnels Construction Company and the New England Structural Company for the energy and ability displayed in carrying out the work substantially in accordance with the original schedule.

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BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

STRENGTHENING OLD BRIDGES.

By LEWIS E. MOORE,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

(Presented October 18, 1922.)

PERHAPS the most important question that arises in considering the strengthening of an old bridge is what loads the bridge will actually be called upon to carry. In the design of a new bridge this question is not so important because the current practice which requires new structures to carry from 80 to 100 pounds per square foot, together with a heavy load concentration such, for instance, as a 20-ton truck, will adequately provide for all usual traffic conditions with a considerable margin for future increase in loads.

New bridges should not be designed to take care of very occasional unusual heavy loads such as steam shovels and other equipment because it is not justifiable to spend public funds to accommodate occasional very heavy loads that are entirely out of the run of ordinary traffic. It is usually easy to lay skids, which will serve to distribute these very heavy loads and so make it safe to move them over the structure. Such provision should be made wholly at the expense of the man who desires to move the unusual load.

Another type of the load problem may arise where an old bridge is operated under traffic restrictions. A case in point is

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the Slade's Ferry Bridge over the Taunton River at Fall River. This bridge has two decks, the upper one carrying electrified steam railroad tracks and the lower one carrying a highway with two trolley tracks. The electrified steam road traffic consists of light cars run in trains of two or three. The restrictions on the bridge were based on the capacity remaining for highway traffic when a steam operated freight train was on the bridge. After the restrictions had been in force for years someone woke up to the fact that the steam train crossed the bridge only twice a day, at about 2 A.M. and 4 A.M. and that at all other times the railroad load was so light that the highway traffic restrictions could be practically removed.

Before the advent of the motor truck, specifications for bridges generally provided for a distributed load of anywhere from 60 to 100 pounds per square foot, and a concentrated load consisting either of a heavy wagon or a steam roller, weighing anywhere from 10 to 15 tons. Very rarely was a single load greater than 15 tons provided for. The advent of motor transportation produced different conditions of loading. To meet these conditions heavier concentrated loads are provided in new specifications, but not much heavier distributed loads.

The specifications of the Massachusetts Public Utilities Department provide for a 20-ton motor truck, which is supposed to be heavy enough to take care of almost any load that may come on the bridge. This load is not yet commonly met with. Within my own experience in the last two years a truck has been operated in the city of Lowell weighing about twenty-two tons. The average is considerably under that and, as a matter of fact, 15 tons is not often exceeded. There are certain trucks regularly carrying cotton from Boston to New Bedford and Fall River which weigh 16 tons.

In studying old bridges inexperienced engineers are very apt to take the latest specification for highway bridges which they can obtain, and study the bridge with reference to the design loads provided in these specifications. If it is incapable of carrying the heavy loads now specified for new designs they condemn it and quite commonly recommend that a new bridge should be built. This is by no means always necessary.

There are a large number of bridges throughout the country which, because of the increasing amount and changed character of loads on the highways, now appear to be obsolete and nearly useless. It is often possible, however, by careful consideration and planning, to get a number of years additional service out of such old structures at a moderate cost. The first element to consider is that of actual loads.

I have a few facts with regard to actual loads from automobile traffic to present. My own car weighs, ready for the road, without passengers, 3 290 pounds, with five passengers it weighs about 4 000 pounds. It is 5 feet 6 inches wide and 15 feet long over the bumpers, and so covers an area of a little over 80 square feet. Four thousand pounds distributed over an area of 80 square feet gives just 50 pounds per square foot. A certain seven passenger touring car of a different make weighs 3 800 pounds, without passengers. With seven passengers, ready for the road, it would weigh about 5 000 pounds. Being 18 feet long over bumpers, it covers a roadway area of practically 100 square feet, which again gives a weight of 50 pounds to the square foot. Ford cars, which constitute the majority of those met on the road, weigh considerably less per square foot. If it were possible to pack a roadway full of automobiles touching each other on all sides you would get then an average load of about 50 pounds per square foot with occasional heavier concentrations, due to trucks. As a matter of fact, such a loading is rarely, if ever, met with.

The actual average loading over the whole roadway may be arrived at by considering traffic on congested city streets. In this case the number of lines of traffic must be considered in order to get the average load per square foot. As an instance, consider the double deck bascule bridge on Michigan Avenue in Chicago. The top roadway is 50 feet wide and I can safely state, having observed the bridge immediately after an opening, that six lines of traffic are all that can be accommodated. For example, the cars I referred to previously weigh 270 pounds per foot of length Six lines of them would weigh 1 620 pounds per lineal foot. The average weight per square foot of roadway is obtained by dividing 1 620 by the width of the roadway or 54

feet. This gives 30 pounds per square foot as an average. This assumes that the cars are touching fore and aft, but not on the sides. Beacon St., Boston, alongside the Common, averages about 40 feet wide, as measured from a city atlas. It accommodates only four line of traffic. Multiplying four by 270 and dividing by 40 gives 27 pounds per square foot on the assumption that each car is touching the next preceding one. Beacon St., between Park and Tremont, is only about 25 feet wide and will only accommodate three lines of cars. Multiplying 3 by 270 and dividing by 25 gives 32 pounds per square foot. Some passenger cars are heavier than those above mentioned, but this is offset by the fact that cars do not touch each other, front and rear, as they are proceeding along the road, so that the length assigned to a car in the above discussion is actually too small. It would appear then that the present type of passenger cars will give an average load concentration on a roadway not greater than 30 or at most 35 pounds per square foot. My own belief is that the smaller figure is more nearly correct.

Now suppose we have an old bridge designed for say 80 pounds per square foot live load, in addition to sufficient capacity to carry its own dead load. If you subtract the average actual live load of 30 pounds per square foot from the 80 pounds live load capacity, you will have 50 pounds per square foot left, which may be regarded as excess live load capacity over and above the actual requirements of traffic. A considerable proportion of this 50 pounds per square foot excess capacity can be used to add material which will strengthen the bridge. In the case of an old structure, it is certainly good judgment to do this, provided the cost of such repairs is less than the cost of a new structure. It is poor economy to throw away a bridge, when at a moderate cost some of its excess live load capacity can be used to strengthen it. In these days of high taxes the taxpayers cannot afford to have their money spent in building new structures unless the economic conditions affecting the bridge under consideration warrant a new structure.

The motor truck must not be lost sight of, but as a general proposition all that is required is to design the floor strengthening so as to care for the concentration which it may produce at any given point.

Sometimes old bridges are condemned because of their vibration under modern loads. I know by experience that proper strengthening will practically eliminate this difficulty. Old bridges are sometimes condemned because they have some certain type of detail. For instance, the hanger used in suspending floor beams from pin trusses is quite often the cause of condemning an old structure. I have examined thousands of bridges, many of them with hangers, and while I have found hangers improperly adjusted and without sufficient provision for transference of load from floor beam to hanger, I have yet to find a broken hanger of this type. I venture to say that such broken hangers are much less frequently met with than are cracked riveted connections. Bridges with this detail can often, by a little judicious strengthening of the detail connecting the hanger to the floor beam, be made sufficiently strong for modern loads.

I have a few instances which illustrate what may be done in strengthening old bridges. The first one is a small bridge involving many of these points mentioned above. It has a span of 127 feet, with trusses spaced only 13 feet on centers, and is located in the city of Northampton. Traffic over it is not heavy, though occasionally a heavy truck uses it. The bridge is of wrought iron, built some time prior to 1885. All of the tension members are loop-rods. Many of the details, particularly of the top lateral system, would not be used to-day. Careful inspection showed that all parts were in good condition. The floor consisted of iron floor beams with wooden stringers and a three-inch wooden plank floor. A Ford car passing over the bridge would cause a tremendous vibration and rattling of the structure. As it then stood, I limited the loads on it to two tons, but after a little study decided that it would not pay to throw away the old bridge. Traffic conditions were such that there never would be any necessity for a wider roadway. The bridge was apparently originally designed for 80 pounds per square foot live load and the dead load amounted to about 30 pounds per square foot. After strengthening, the total dead load was about 60 pounds per square foot, which absorbed 30 of the 80 and so left 50 pounds per square foot live load capacity. The individual details are such that it will also carry a single 20-ton truck.

The strengthening consisted of putting in new hangers, new steel floor beams, new steel stringers and a 4-inch concrete slab floor. It was impracticable to connect the laterals at the bottom of the posts without incurring considerable expense. Inasmuch as the concrete slab floor, when completed, would render a lateral system unnecessary, I decided to attach the lateral system to the bottoms of the outer stringer at points close to the floor beams and to make them of rods with threaded ends. A nut at each end served to tighten the lateral enough to hold it in place and stiffen the bridge laterally until the floor slab was completed. In handling this job in the field, we took out not over two panels of the floor system and laterals at a time in order to prevent the bridge from collapsing sidewise.

The design of the parapet is novel. In most highway bridges one of the sources of serious trouble is the accumulation of dirt and debris on the bridge seats. This is rarely swept off and usually rusts out the points of support. The parapet was designed to eliminate this difficulty. In principle it consists of building a parapet whose coping is at the same height as the top of the curb and which extends a sufficient distance beyond the trusses to adequately protect them from dirt and debris. The parapet is notched out at the right height to support the floor slab, together with its curbs. The floor slab, when it is poured, must be prevented from bonding to the parapet. The strengthening entirely eliminated the vibration. The total cost was $3 778.50, about $2.29 per square foot.

Another type of bridge strengthening which possesses some unusual features and may be of interest was that of two lattice truss spans 160 feet long, (Fig. 1). The town having charge of the maintenance of this bridge found it necessary to replace the existing wooden floor and decided to replace it by pre-cast concrete slabs resting on the stringers. After the slabs were cast, certain questions were raised which resulted in my being brought into the matter. After careful study of the situation, I made up my mind that the best course to pursue was to place the pre-cast slabs as planned and strengthen the floor system by placing intermediate floor beams in the center of each panel. These floor beams were riveted to the trusses at their ends and

supported by new hangers connected to the intersections of the truss, which was a quadruple system lattice girder. The collision struts at the ends of the trusses were the only original truss members which required strengthening. Stiffeners were riveted to the stringers at their centers and they were blocked up on the new floor beams by steel shims about three inches in height. The reason for making these shims so deep was to allow the existing

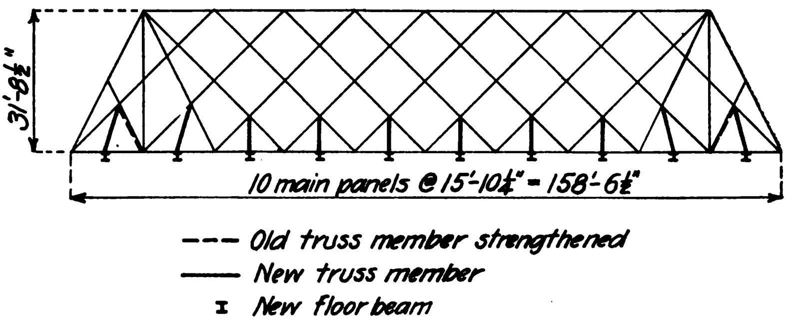


FIG. 1 — METHOD OF STRENGTHENING TWO LATTICE TRUSS SPANS.

lateral system to pass over the new floor beams without disturbance. There was one trolley track on the bridge near one truss. This method of strengthening not only doubled the strength of the stringers for concentrated loads, but also relieved each existing floor beam of nearly half of its dead load, thereby increasing its live load capacity. The construction recommended for the street railway track was steel ties with rails fastened to them and concrete slabs poured in place. This construction was afterwards modified for reasons which had nothing to do with the engineering feature of the situation.

Using a live load of 68 pounds per square foot with a single 20-ton truck and a 50-ton trolley car placed anywhere, the top chord would be overstressed in the center panel 13 per cent. and one of the tension diagonals would be overstressed the same amount. Inasmuch as it is doubtful if the average load on the highway ever exceeds 30 pounds per square foot, it is probable that the bridge is never actually overstressed at all.

Figure 2 shows an entirely different type of strengthening which was first installed in a bridge in Holyoke in 1914. The bridge consisted of two spans of very light continuous trusses over a water-power canal. The ice froze on one side of the stone masonry pier, with the result that occasionally it would tip 3 or 4 inches out of line. After the ice was melted, or cut away from the pier, it would settle back to its original position. This movement of the pier would damage the truss whenever it occurred. Because of the conditions, trolley traffic was discontinued over the bridge.

I was asked by City Engineer McCarthy to suggest a means of strengthening the bridge so that trolley traffic could be resumed. I suggested taking out the wooden stringers under the trolley track and substituting 15-inch Bethlehem girder beams, which would extend unbroken from each abutment to the center pier. Such beams are strong enough to support a 30-ton trolley car over the full span of 50 odd feet. The deflection of the beams alone, under such conditions, figures about 2 inches, but the actual effect of such beams is to distribute the load between the different floor beams and the longitudinal beams themselves. The actual result is that there is very little deflection, but a very great stiffening of the structure. A parapet was built on the center pier, thoroughly anchored to the bridge seat, as shown, and the girder beams were butted against this wall and also solidly against the parapet walls of the abutment, no room being left for expansion. The effect was that the pier never tipped again; the bridge was stiffened enough so that there was no perceptible deflection under trolley car traffic; and truck drivers used it in preference to other bridges over the same canal because of its stiffness. The cost of this work, which was done in 1914, was about $1 200.00. The same scheme has been used in other places with similarly good results. In one case it was applied to a wooden truss bridge with very satisfactory results.

An entirely different problem was presented in the case of two spans, one a truss about ninety feet long and the other a girder about forty feet long (Fig. 3). This is a highway bridge with one street railway track at one side of the roadway. The bridge itself consisted of very light sections, very badly corroded,

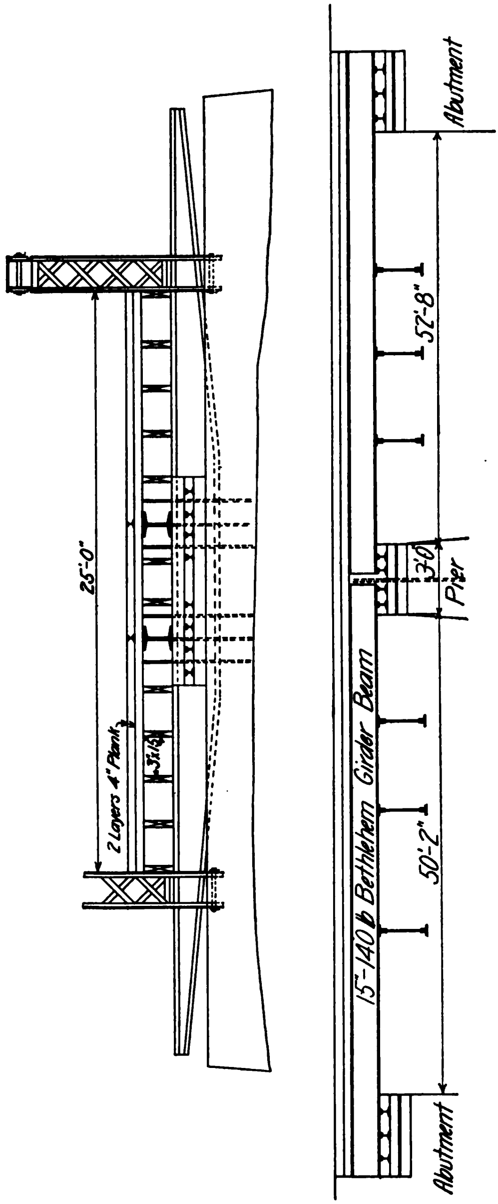
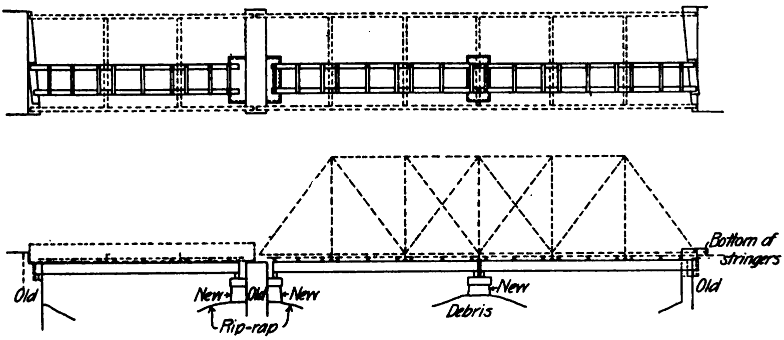


FIG. 2 — METHOD OF STRENGTHENING BRIDGE, AT HOLYOKE, MASS.

and beyond the possibility of strengthening in its entirety at any reasonable cost. The Street Railway Co., however, was desirous of strengthening its track.

Apparently the existing bridge had been preceded by three spans, probably of wooden stringers, as the debris of the old pier is still in existence in the middle of the truss span. There is considerable heavy rip-rap around the existing pier. This rip-rap and debris of the old pier are above the water level at



Dotted lines show old steel. Stringers are omitted.

FIG. 3 — METHOD OF STRENGTHENING BRIDGE UNDER STREET RAILWAY TRACKS.

most times and have not altered their position in the last twelve years, to my own knowledge. I therefore decided to build a small concrete pier on the debris of the old one, two small buttress piers on the rip-rap around the existing pier and to notch out the existing masonry in the abutments for new bridge seats, all with the purpose of placing longitudinal girders beneath the existing stringers and transferring the load on the stringers to these girders, thus relieving the highway bridge of any responsibility for Street Railway loads.

The Street Railway stringers of the highway bridge are directly supported on new H's, extending crosswise from one new girder to the other. These H's are so located that they break up the individual stringer spans so that instead of being about fifteen feet, they become not more than 6 feet. This work is now in progress.

Some will undoubtedly criticise the placing of piers on debris and on rip-rap, as is done here, but it should be borne in mind that this debris has been unchanged for years and that even in the unlikely event of a wash-out of one of these piers, the old structure would still be there on its old supports. In this case I do not think that there would be any economical justification for going below the debris or rip-rap in order to obtain theoretically better foundations for the new masonry.

The new girders are placed by sliding them in sidewise on the piers and abutments and then jacking them up until the new H's bear on the under side of the old stringers. Castings are then put on the abutments and piers underneath the girders to carry them. These castings are about 15 inches deep in this case.

The above are a few illustrations of rather unusual methods of strengthening, each one of which was intended to be adapted not only to the purely engineering, but also to the economic requirements of the situation.

DISCUSSION.

B. W. GUPPY.* I have found Mr. Moore's paper very suggestive. It is our duty to get as nearly as can safely and economically be done, the last pound of service out of our bridges, and have repaired or strengthened fully 250 bridges in the last ten years. The word strengthening is often loosely applied to work that should be classed as repairs although to be sure the bridge is stronger after the work is completed than it was before. We are governed by the I. C. C. classification. Work that is done solely to restore the bridge to its original capacity is classified as repairs and charged to operating expenses. Work that is done to increase the original capacity of the bridge is classified as betterments and charged to capital account.

The two operations are similar. Ordinarily the work has to be done under traffic and with the least possible interference with traffic.

The necessity for repairs is due to neglect, accident, improper design and construction, overloading and malice afore-

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thought. The reason for strengthening is obvious. It is desired to put heavier loads on the bridge than it can safely carry in its present condition.

Our method of procedure is simple.

If there are no plans of the bridge available measure in detail. If there are plans check them against the structure. We have found enough variations between plans on file and structures in the field to make this rule obligatory. Make a thorough inspection at the same time to determine the necessity for repairs. Arrange to have the repairs made in connection with the work of strengthening.

The draftsman is required to take a set of prints to the site and sketch on them the location, nature and extent of all defects discovered. A stress sheet is next made for the proposed load and a careful investigation of all details. Studies are then made to determine whether the bridge can be strengthened to carry the proposed loads, whether safety or economy require the use of falsework and whether it will be cheaper to strengthen or to rebuild. Additional strength may be obtained by applying additional material to certain members, by replacing certain members with stronger members, by inserting additional members (including entire girders or trusses), or any combination of these three methods. Repairs are effected by cutting out defective and splicing in new material, by applying additional material or by revision of details. In making repairs due to failure of details plan the work to avoid a repetition of the failure.

Unless means are taken to relieve the member being strengthened of dead load stress the additional material will only carry its proportion of the live load stress plus the stress due to any dead load added to structure after member is strengthened. Members may be relieved of stress by forcing panel points apart or pulling them together or by wedging up the entire structure on falsework. In most cases it is cheaper to be liberal with the added material and not attempt to redistribute the dead load stress.

On account of the increased cost of doing work under traffic the greatest practicable amount of work should be done on the material before it is placed in its final position.

At first thought it would seem simpler to make good, loss due to corrosion by applying additional material, but it is generally more satisfactory to cut out the old and splice in new material. The irregular surface due to corrosion does not permit of close contact and tight rivets and the cost of thoroughly cleaning and painting same is disproportionately high. For this reason we now require top flanges of girders, floorbeams and built up stringers to have at least one cover plate the full length of the flange. Then loss due to corrosion can be easily made good by renewing the flange plate.

A carefully worked out program of operations is necessary in order that the work may be carried out safely and economically. A great deal of work can be safely done without any falsework being necessary. When there is sufficient time between trains, falsework for supporting dead load only and perhaps the construction equipment may be all that is necessary. In other cases falsework for carrying traffic may be required.

Most of the work done under traffic without the use of falsework consists in applying additional material or in cutting out and splicing in. When the truss has boxchords with double webs and I or H shaped web members, work on only one side of chord or web member of one truss at a time. On highway bridges confine traffic to one half of the roadway while working on the other side. When a truss has T shaped chords and web members, trestling is a necessity. We once had a very regrettable and unnecessary accident due to neglect of this precaution. A deck highway bridge had several lines of trusses. The interior trusses were double webbed, the exterior ones were T shaped. The bridge was over a busy station platform and it was planned to keep in falsework only while work on the outside trusses was under way. The foreman of the repair crew successfully repaired the interior trusses and without giving notice that he was ready to work on the outside trusses and without waiting for the falsework he had been told was necessary cut the flange angles off of one end post of an outside truss. The result was several casualties and some interruption to traffic, but no fatalities. No train was due and no passengers on the platform.

In one case the top flange angles only of the stringers of a single track deck truss of nine panels required renewal. As the

work had to be done under traffic it seemed simplest to renew the stringers between trains. The material cost would have been great. We bought two entire new stringers and the necessary flange angles for the others. The old stringers in one end panel were replaced by the new ones. New flange angles were riveted on this pair of old stringers and they were substituted in the second panel and so on till all stringers had been changed out and we were left with an old pair of stringers which were scrapped. The angles cut from the first pair of stringers were used as templates for drilling the new angles so there was no delay from this source. The only work done under traffic was cutting out and driving the rivets in the stringer connections.

The top of a number of bridge piers have been rebuilt or remodelled with the use of a minimum amount of falsework. Between trains the truss was jacked up on a bent placed near the pier and work of tearing out and rebuilding proceeded until a train was due, when truss was lowered onto blocking on pier to carry train. The new stones were cut to close fit so there was no delay. Concrete would have been cheaper per cubic yard but the cost of falsework to carry trains while the concrete was setting made the method adopted much the cheaper.

We are now completing our most extensive job of bridge strengthening. The bridge at Newburyport over the Merrimac River. The bridge is a double track bridge with seven fixed and a swinging draw span. The bridge consisted originally of three lines of trusses with floorbeams and stringers. We are placing two additional trusses midway between the present trusses and replacing the floor and bracing with stronger members. Traffic is confined to one track while work is under way on the other half of the bridge. No falsework is required. An entirely new structure would involve an additional expenditure of about $80 000. A fuller account of this work will appear in an early issue of the *Engineering News-Record.* A word of caution in regard to trestling old bridges. A bent at the center of a Towne lattice truss is the proper method of strengthening; at the center of a Howe truss it is a crime. If a bent is desired near one end only, remember that web stresses are increased and investigate to see that members are not overstressed.

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

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A LONG SPAN REINFORCED CONCRETE GIRDER BRIDGE AT COHASSET NARROWS.

BY BARZILLAI A. RICH,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

(Presented October 18, 1922.)

THE Cohasset Narrows Bridge lies in the towns of Wareham and Bourne, Massachusetts. The Cohasset Narrows are located just west of the Buzzards Bay end of the Cape Cod Canal and connect Buttermilk Bay, a shallow tidal pond of some 500 acres in extent, with Buzzards Bay. The New York, New Haven and Hartford Railroad crosses the Narrows about one-half mile from Buzzards Bay. About 1891, a wooden pile highway bridge was constructed across the Narrows some 650 feet above the railroad bridge. Later a bridge carrying a street railway was constructed adjacent to and above the highway bridge. The highway crossing this bridge is the main highway to the south side of Cape Cod. Since the advent of the automobile the travel over this highway has increased very rapidly. The location of the old bridge was such as to require several dangerous curves in the highway between it and the village at Buzzards Bay Railroad Station.

The condition of the old highway bridge becoming such as to require its renewal, the Cohasset Narrows Bridge Commission, consisting of the County Commissioners of Plymouth and Barnstable Counties, was established by Chapter 165 of the General

* Of Fay, Spofford & Thorndike Consulting Engineers, 200 Devonshire St., Boston, Mass.

Acts of 1918 for the purpose of reconstructing the bridge. The Commission was given power to determine a new location so as to improve the alignment of the highway.

Studies for the location of the bridge had previously been made by the Massachusetts Highway Commission, which later became the Division of Highways of the State Department of Public Works, and the Commission determined on an approximate line for the new highway. This line was an extension of the existing highway in the town of Wareham across the Narrows with slight curve connecting it to the existing highway near the Buzzards Bay Railroad Station.

In November 1919, the Bridge Commissioners retained Fay, Spofford and Thorndike of Boston as engineers for the designing and construction of the new bridge. A careful study was made of several routes approximating the line above mentioned. Soundings were taken in the vicinity of the site and wash borings were made at the site to determine the surface and sub-surface conditions.

Measurements made showed that there had been considerable scour at the railroad bridge since it was reconstructed in 1912. The tidal range at the Buzzards Bay entrance to the Cape Cod Canal is given in the tide tables as 4.1 feet. This variation in tide caused a large volume of water to pass through the Narrows at each change of tide.

Current measurements were taken by means of wooden floats, having a draft of from 2½ to 7 feet. The path of each float was obtained by locating its position by triangulation at about one minute intervals. The position of each float at the time of each observation was plotted and where necessary an interpolated point was plotted so that the distance between points was the approximate distance covered in a minute. In this way the direction of movement during any minute and the distance traversed was indicated on the plan. The paths of the floats used on flood tide were shown by solid lines and of those used on ebb tide by dotted lines. The greatest velocity was near the position of the second span from the north, and the floats drifted toward the location of that span. The contours interpolation from the soundings show this place to be the deep-

est part of the waterway. The average surface velocity was found to be about one foot per second or about seven-tenths miles per hour and the maximum velocity was about two feet per second or about one and four-tenths miles per hour at both ebb and flood tide. It will be noticed that the location chosen places the center line of the bridge practically normal to the current.

The borings showed the upper 10 feet of the soil to be very coarse sand and gravel. There were several large boulders above the surface, particularly on the Bourne side of the Narrows and the borings indicated that there were boulders in the underlying soil.

The Cohasset Narrows being navigable waters, it was necessary that provision be made for the installation of a draw if future conditions should warrant it. The draw in the railroad bridge, however, had not been opened during the previous twenty-five years so far as could be ascertained. The navigation in the Narrows and Buttermilk Bay is by pleasure craft and small fishing boats. As the existing railroad bridge gave a clearance which had proved satisfactory for many years, approximately the same clearance was adopted for the new bridge. The maximum clearance above mean high water is 9 feet at center span of the new bridge and 8.9 at the draw in the railroad bridge. These clearances proved satisfactory to the United States Engineers and the license was granted with the understanding that a draw could be installed if required in the future.

Many studies were made of various types of bridges such as steel girders, concrete arches and concrete girders of various lengths of span. The result of these studies was the adoption of a concrete girder bridge of five spans of 56 feet 6 inches each in the clear between copings of piers. (Figs. 1 and 2.) The arch bridge did not prove as economical as the girder bridge. The two principal reasons being that the arch bridge required that the highway be placed at a considerably higher elevation to provide sufficient clearance; and that, as provision for a draw was necessary, two of the piers would have to be of the abutment type and thus greatly increase the cost. It was found that the use of a 1 to 4.5 mixture of concrete was the most

FIG. 1 — COHASSET NARROWS BRIDGE.

FIG. 2 — COHASSET NARROWS BRIDGE.

economical to use. The higher allowable stresses permitted the use of longer spans for the same dead load than could be obtained with the 1.6 mixture commonly used for this class of work. The soil and water conditions being such as to make the construction of the foundations exceptionally expensive it was necessary to make the spans as long as possible to obtain an economical structure.

The bridge is 32 feet wide in the clear between side railings, there being a 26 foot roadway, with a 5 foot walk on one side and a 1 foot wheelguard on the other. The length of the bridge between faces of abutments is 303 feet. The piers are of sufficient length to permit the placing of an additional light girder outside the present side girders on the sidewalk side. By moving the present railing to the outer side of this girder a sidewalk can be constructed so that the present roadway can be widened to some 30 feet. This would then provide sufficient space for a railway track in the center with a line of vehicles on each side. It was assumed that the trolley line might be placed on this bridge when the existing street railway bridge should wear out.

The live loads adopted for use in the design of the slab and girders were as follows: For the slab a 20-ton truck with 25 per cent. for impact, each rear wheel being considered to be distributed over a width of 6 feet. For the interior girders a train of two 50-ton cars with 22 per cent. for impact, and one-half of a 20-ton truck with 25 per cent. for impact. For outside girders a 20-ton truck with 25 per cent. for impact. These live loads are those specified in "Specifications for Bridges Carrying Electric Railways," adopted by the Massachusetts Public Service Commission, Revised March, 1915.

The stresses in the concrete in the superstructure were kept within the maximum allowed by the Joint Committee report of 1916, that is, for the 1.4½ mixture, they were as follows:

Bending	812 lbs. per square inch
Shear	125 lbs. per square inch
Bond	100 lbs. per square inch
Bearing	563 lbs. per square inch

The soil being sand, gravel and boulders to a depth of twenty or more feet below the surface, it was decided to place the foundations directly on it. The area of the waterway of the new bridge being only 22 per cent. greater than the existing railroad bridge, where considerable scour had occurred, the bottoms of the footings were placed about five feet below the ground surface.

The abutments are of the "U" type, the wingwalls being cantilevered in order to reduce the area of the cofferdams to a minimum. The concrete in the footing part of each abutment was placed under water within a steel sheet pile cofferdam having the same dimensions as the footing. The abutments are faced with granite from elevation 87.0, about one foot below mean low water, to elevation 96.0 above all but the extreme high tides, this part being alternately exposed to the sea water and the air. Above the granite coping, elevation 96.0, the abutment and wingwalls are of reinforced concrete. The highest water of which record could be found was 97.13, or about 7.00 above Mean Sea Level. The datum used being 90.13 below Mean Sea Level.

The piers are similar in construction to the abutments. There is, however, a course of concrete between the footing course and the granite facing on account of the greater depth of the foundations. The piers have curved cut-waters to reduce the obstruction to the flow of the water to a minimum. The tops of the piers are 6 feet 3 inches wide. A construction joint was placed 18 inches from the tops of the piers. This upper 18 inches contains the expansion bearings on one side of the pier and the fixed bearings on the other. These bearings were placed in position before this upper layer of concrete was deposited.

The piers were all designed considering that any span could be removed and a draw span substituted if necessary. The soil pressure was determined considering the maximum reaction from one span and the dead load only from the other span, the pier being submerged to low water only. The effect of removing one span and having the remaining span carry the maximum live load was also considered. The maximum soil pressure was about 6 000 lbs. per square foot.

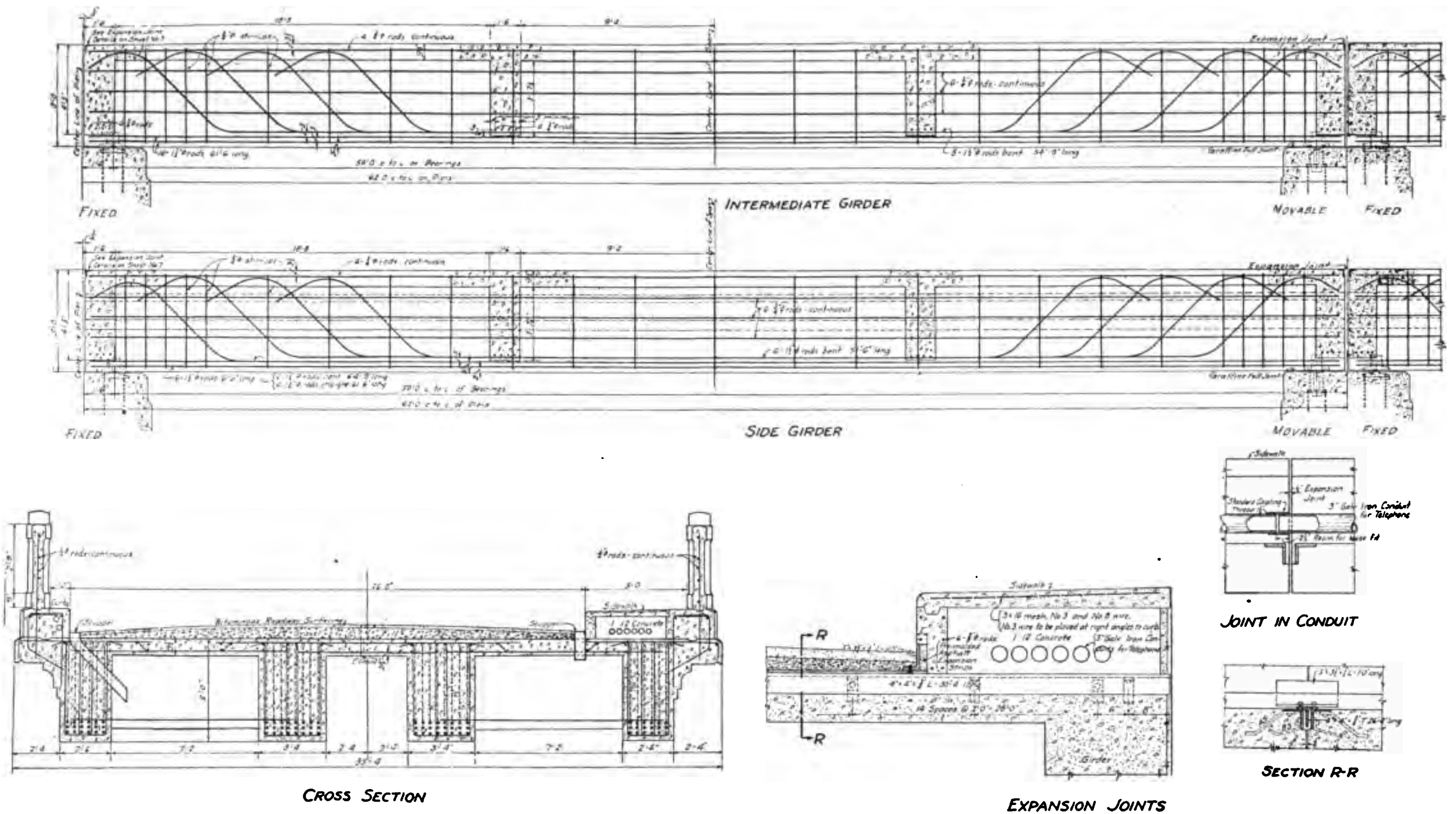

FIG. 3 — COHASSET NARROWS BRIDGE — SUPERSTRUCTURE DETAILS.

The superstructure of each span of the bridge was composed of four longitudinal reinforced concrete girders each 59 feet center to center of bearing composed of concrete mixed in the proportion of one part cement to four and one-half parts of aggregate. The two interior girders were designed to carry a live load of a train of two 50-ton electric railway cars and the side girders to carry a live load of a 20-ton truck. The allowance for impact and the stresses allowed have been previously given. The ends of the girders were connected by a concrete cross beam and two light cross beams were placed between the ouside and the interior girders at the third points. (Fig. 3.)

The deck of the bridge was made flat and the crown given to the roadway by filling to allow for a future railway track. A two-inch bituminous wearing surface was placed on the clean gravel filling. Small drains were placed through the slab to drain the filling. Scuppers were placed in each span to drain the roadway surface.

The expansion joints in the deck between the spans were formed by imbedding two steel angles in the upper edge of the slab and placing a 4 x 4 tee with its stem in the joint between the spans. A special detail was used at the curbs composed of a steel angle riveted to the tee and backed by a pre-molded expansion strip. These expansion joints have worked well and there is no indication on the surface of the roadway of the movement of the concrete structure. The expansion joints in the walls and railings are filled with heavy wool felt saturated with paraffin. At the time of a visit made about two weeks ago, the girders had expanded slightly due to the warm weather and the felt showed signs of having been compressed.

The conduits for electric wires were placed under the granolithic sidewalk. Movement at the expansion joints was provided for by reaming out a coupling attached to the pipe on one side so that the pipe from the other side formed a slip joint.

The long concrete spans meant that there would be considerable longitudinal movement due to varying temperatures, also that the bearing stress at the edge of a pier would be greatly increased by the deflection of a girder under maximum live loads. It was, therefore, decided to place the fixed end of the girders

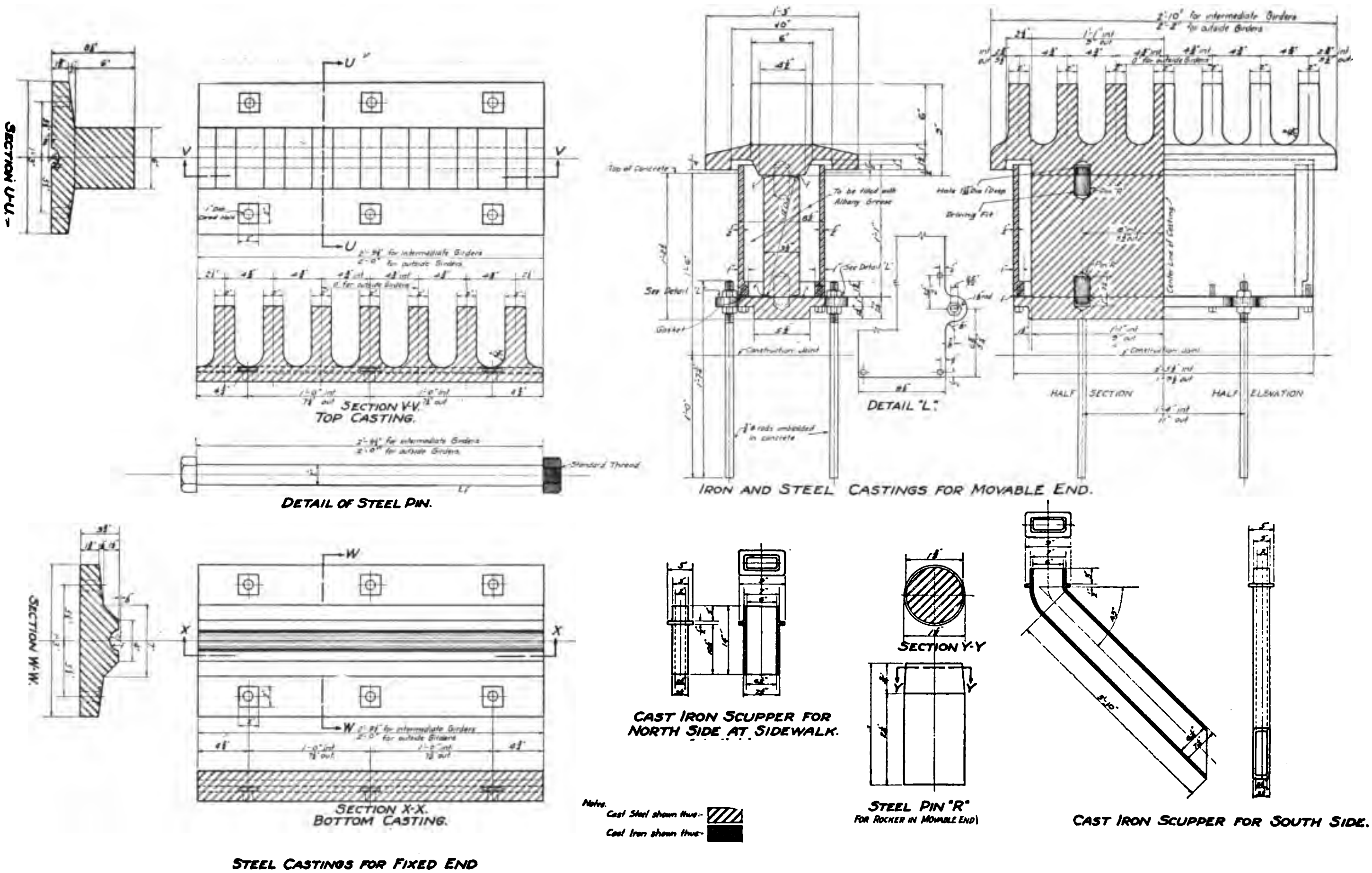

FIG. 4 — CASTINGS. COHASSET NARROWS BRIDGE.

on pin bearings so that the deflection of a girder would bring no excess pressure on the pier or abutment. The expansion end was placed on a single cast steel segmental roller thus providing a single bearing and preventing excess pressure at the edge of the pier and at the same time permitting that end to move longitudinally with ease. The fixed end bears on 2 inch steel pins, the only novel feature being the manner of connecting the upper casting to the girder. To connect this casting securely to the girder, ribs were cast to extend into the girder. These ribs ran in the direction of the length of the girder and were spaced so that the reinforcing rods passed between them. In this way any tendency of the girder to separate from the plate was obviated. (Fig. 4.)

A considerable amount of study was necessary to design a satisfactory expansion bearing before the one shown was decided on. The bearing decided on is both simple and efficient. It is formed of a 12-inch diameter segmental roller under each girder and provides for the deflection of the girder and for horizontal movement with one bearing. The two pins in each face of the roller prevent its working out of place. The upper casting of this bearing is designed the same as the upper casting of the fixed end. As this joint could not be examined in the future in the manner that it could be on a steel bridge it was decided to place it in a cast-iron box and fill the box with a heavy grease. This box was placed in upper course of concrete of the pier and the top of the box comes a short distance above the ordinary top of the pier. The casting attached to the girder fits over this box and forms a weatherproof joint. The joint between the pier and the girder was formed by a one-half inch layer of parafined wool felt.

The anchor bolts for the bearings were embedded in the part of the pier under the construction joint 18 inches below the top of the pier. The bearing plates were carefully adjusted in position by means of double nuts on the anchor bolts before the upper part of the pier was concreted.

The contract for the construction of the bridge was let to Holbrook, Cabot & Rollins on June 28, 1920 for the sum of $200 000 for the bridge alone. Work was begun about July

20, 1920 and the bridge open to traffic July 2, 1921, the superstructure being all constructed in the spring of 1921. The work was started on the northerly or Wareham shore. For the north abutment and the northerly piers the area of the foundation was dredged approximately to grade and the steel sheet pile cofferdam then driven. Such little further dredging as was required was done inside the cofferdams. The southerly piers and abutment were constructed by first driving the cofferdam and then dredging the material inside. On this side there were several boulders within the cofferdam which required blasting. The piling was considerably damaged in driving and was very difficult to withdraw after the piers were constructed. As soon as the dredging in the cofferdams was completed, concrete was placed with bottom dump buckets to form the lower course of the foundation. This lower or footing course filled the area of the cofferdam and formed a seal. As soon as this concrete had set the cofferdams were pumped out and the remainder of the pier or abutment placed in the dry. The cofferdams proved to be sufficiently tight although the driving was very hard. After the completion of the pier and abutments all sheeting and piles were removed.

The forms for the superstructure were all made in a mill and assembled on the job. They were supported on piles which were pulled out when no longer needed. The steel reinforcing was erected on shore and carried to the girder and lowered into position as one unit. The railings were cast in place using a light colored aggregate. After the concrete had become hard the surfaces of the railings were bush hammered with 6 cut hammers. The finish obtained is both pleasing and durable. The lamp posts were pre-cast of the same aggregate as in the railings and while very simple in design add a great deal to the attractiveness of the bridge.

Vol. IX NOVEMBER, 1922 No. 9

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

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MOSQUITO CONTROL IN MASSACHUSETTS.

By George C. Whipple,* Member Boston Society of Civil Engineers.

(Presented before The Sanitary Section, October 4, 1922.)

By concerted action it will be possible to eliminate the mosquito nuisance in the inhabited parts of Massachusetts; it will not be practicable to eradicate all mosquitoes. At the outset we are confronted with a quantitative distinction hard to establish. How many mosquitoes does it take to make a nuisance? In the bedroom, one is enough; on the front porch or in the garden, one mosquito bite an hour as a maximum would not interfere seriously with outdoor life. It is not the occasional buzzing or biting of a mosquito which makes a nuisance; it is the concerted attack of half a dozen or perhaps a hundred and their continued presence day after day, which makes rational outdoor life impossible and which in many ways injures the health and comfort of the people. A practical measure of the mosquito nuisance may be found in the popular recourse to profanity. Three stages may be distinguished. In the first stage you swear at the mosquito, using any appropriate phrase from "Oh, dear!" to "Damn!"; in the second stage you swear at somebody because something isn't done; in the third stage you swear that you will do something yourself. For generations the people of Massachusetts have been swearing mad against the mosquito; last summer they became fighting mad. The Anti-

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Mosquito Association of Massachusetts was organized. Thanks to the coöperation of the press the people of the state know about this association, but the news does not seem to have reached the mosquitoes, for even at this date (October 4) they are still rampant. The object of this association as stated in its constitution is "to stimulate interest in the suppression of mosquitoes and other insects which affect human comfort and health; to secure and spread information and to urge coöperative efforts by individuals, associations, communities, and their governments to the end that these insect nuisances may be done away with." It was realized at the outset that little could be done until a substantial organization had been effected, definite plans made and funds collected, hence no efforts were spent in summer skirmishing. The fight against the mosquito will not be successful unless it has a plan of campaign based on scientific knowledge and put in operation over a wide area. It will be the work of the association this winter to arrange a plan of action and bring it to the attention of the cities and towns of the state, especially those of the Boston metropolitan area in order that the work of mosquito suppression may be undertaken early in the spring.

Life History of the Mosquito.

So much has been written about the mosquito that it is quite generally understood that this insect has a life cycle which includes three aquatic stages, the egg, the larva, and the pupa, and one winged stage, the mosquito. It is an accepted scientific fact that water is necessary for mosquito development, but mosquitoes are found so often in places where there is no apparent standing water that the public is still skeptical on this point. It is very easy to say that the female mosquito lays her eggs in water; that after a time these hatch and become larvae, or wigglers; which in turn become pupae, or tumblers; and that from the pupae the mosquitoes emerge and fly away. This indeed is the rule, but now comes the difficulty. Mosquitoes are not all alike. There are dozens of species, and the different species have different habits. Some mosquitoes lay their eggs in salt or brackish water, some in fresh water swamps, and some in

the rain water which collects in pools, puddles, gutters, tin cans, or even holes in trees. Other mosquitoes with faith in nature lay their eggs on damp ground where instinct tells them water will sometime come and remain long enough to hatch out their eggs. Some species have but one brood a year; some have successive broods as long as warm weather lasts and water can be found for eggs. I observed a curious fact last summer. The heavy rains of June and the succession of summer showers caused a tremendous mosquito crop at my home in Cambridge, while at my farm in New Hampshire there were fewer mosquitoes than for many years. Why this difference? The Cambridge mosquitoes were of the common house variety, which has successive broods all summer long. The Fitzwilliam mosquitoes were a Canadian woodland type which has but one brood and that early. The heavy rains of May and June (14.26 in. in June) washed the eggs and larvae out of their breeding places and carried them downstream. Few were left to trouble us. The early breeding habit of the species found at my farm is evidenced by the local saying that "when the flies come the mosquitoes go." There is no such saying in Boston.

Mosquito larvae have their differences. The larvae of most species live near the surface of the water or go to it frequently for aid; but there is one species that passes its larval stage at the bottom, evidently getting its oxygen from the roots of sedges. Applying oil to the surface of the water would not eradicate such larvae.

Mosquitoes differ in their winter habits. In some species the adult mosquitoes hibernate, hiding away in cellars and old buildings, usually in the dark, and emerging in the spring ready for business. In some species the eggs are laid in the fall, retain their vitality through the winter, though frozen, and hatch in the spring. In some species both the eggs and larvae withstand freezing.

Mosquitoes differ in their flying habits. The house mosquito seldom travels more than a few hundred yards from the place where it hatched; but the salt marsh mosquitoes often fly or are blown several miles. The mosquito which transmits yellow fever is a short flier; hence it is relatively easy to control it. The

mosquito which transmits malaria flies farther; hence in order to control malaria it is necessary to extend suppression activities over much wider areas.

Some mosquitoes take delight in entering houses and will seek out minute unprotected means of access, holes and cracks in screens, key-holes, chimneys; they will light on your shoulder while you are unlocking the front door and let you carry them in. Once in they will lay eggs in a water closet tank, or a vase of flowers, and people will wonder how they could possibly get through the screens. As a matter of fact few species of mosquitoes will get through a No. 16 screen; some mosquitoes will go through a No. 12. Some species seldom try to enter houses.

Without going further into details, it will be seen that in order to suppress the nuisance it is necessary to know what sort of mosquitoes we have to deal with, for measures appropriate to one species might be useless with another, and if improper measures are undertaken much money may be wasted, and discredit brought on the whole movement. Hence the problem is fundamentally one of entomology.

Kinds of Mosquitoes.

Entomological science has made great advances in recent years. New species of mosquitoes have been described by students in different parts of the world and given new names. In many cases the same sort of mosquito has been baptized with different names, both of species and genus, and inevitable confusion has resulted. This is equally true of all zoölogical science. Little by little entomologists are weeding out the duplicate names and giving permanent assignment of generic and specific titles warranted by priority according to the rules of scientific nomenclature. The result is that some names which have become well known are being replaced by earlier, though unfamiliar names. For example, the yellow fever mosquito is no longer *Stegomyia fasciatus* but *Aëdes calopus*, and one of our Massachusetts friends is no longer *Culex sylvestris*, but *Aëdes vexans*.

The best available treatise on the classification of the mosquitoes is Harrison G. Dyar's monograph on "The Mosquitoes of the United States," published in 1922, as No. 2447 in the Pro-

ceedings United States National Museum, Vol. 62, Art. 1, and reprinted by the United States Public Health Service.* It contains descriptions of the various genera and species with their synonyms and with references to localities where they have been found. Another recent and very excellent book is "Mosquito Extermination," by W. E. Hardenburg, published by McGraw-Hill, 1922, New York.

From Dyar's list we find that the following species have been found in Massachusetts. They all belong to the order of Diptera, family Culicidae, and tribe Culecine.

LIST OF MASSACHUSETTS MOSQUITOES, COMPILED FROM DYAR'S MONOGRAPH.

GENUS *Culex* Linnaeus
- *C. testaceus*, van der Wulp
- *C. pipiens*, Linnaeus
- *C. territans*, Walker
- *C. salinarius*, Coquillett
- *C. melanurus*, Coquillett

GENUS *Culiseta*, Felt
- *C. dyari*, Coquillett
- *C. inornatus*, Williston

GENUS *Mansonia*, Blanchard
- *M. perturbans*, Walker

GENUS *Psorophora*, Robineau-Desvoidy.
- *P. ciliata*, Fabricius
- *P. sayi*, Dyar and Knab

GENUS *Aëdes* Meigen
- *Aë. trivittatus*, Coquillett
- *Aë. aurifer*, Coquillett
- *Aë. intrudes*, Dyar
- *Aë. punctor*, Kirby
- *Aë. hirsuteron*, Theobald
- *Aë. dorsalis*, Meigen
- *Aë. canadensis*, Theobald
- *Aë. excrucians*, Walker
- *Aë. stimulans*, Walker
- *Aë. cantator*, Coquillett
- *Aë. fitchii*, Felt and Young
- *Aë. cinereoborealis*, Felt and Young
- *Aë. atropaltus*, Coquillett
- *Aë. taeniorhynchus*, Wiedemann
- *Aë. sollicitans*, Walker
- *Aë. triseriatus*, Say
- *Aë. vexans*, Meigen
- *Aë. cinereus*, Meigen

GENUS *Anopheles* Meigen
- *Aë. punctipennis*, Say
- *Aë. quadrimaculatus*, Say
- *Aë. Walkeri*, Theobald

Of this list of thirty, which by no means includes all the known species, only about half a dozen play a major part in our mosquito nuisance.

* Our standard American work, "The Mosquitoes of North and Central America and the West Indies," by Howard, Dyar, and Knab, Carnegie Institution, 1912-1917, is now out of print.

I will not attempt to describe the various species in biological terms. This is beyond me and I will leave it to Dr. C. T. Brues, Assistant Professor of Economic Entomology, Harvard University, who has kindly consented to contribute to this discussion. I may say that while laymen may easily come to recognize the more common mosquitoes from their appearance, it requires a trained entomologist to make positive identifications, because the difference between species are often very minute and may involve a study of the male as well as female, and the larvae, as well as the mosquitoes themselves, a microscope being necessary to make some of the discriminations.

Perhaps it will be more useful for us to classify the common mosquitoes according to their usual habitat. We thus have these groups, which may be called the House Group, the Salt Marsh Group, the Fresh Water Woodland Group; to which may be added the Disease-Carrying Group. This classification, it must be admitted, is not a definite one, as there is some over-lapping.

House Group

Culex pipiens, the common dark brown, rain barrel mosquito.
Culex territans (*Culex restuans*).

Salt Marsh Group

Aëdes sollicitans (*Culex sollicitans*). White banded, salt marsh mosquito.
Aëdes cantator (*Culex cantator*). Large brown, salt marsh mosquito.
Aëdes taeniorhynchus (*Culex taeniorhynchus*). Small salt-marsh mosquito.
Culex salinarius. Brackish water, rather than salt water.

Fresh-Water Woodland Group

Aëdes vexans (*Culex sylvestris*; *Aëdes sylvestris*). Common marsh mosquito.
Aëdes stimulans (*Culex stimulans*; *Culicida subcantanus*). Brown woodland mosquito.
Aëdes canadensis (*Culex canadensis*). Woodland pool mosquito.
Mansonia pertrubans

Disease Carrying Group.

Aëdes calopus (*Stegomyia fasciata*) transmits yellow fever; not found in Massachusetts.

Anopheles quadrimaculatus, transmits malaria.

Anopheles punctipennis, transmits malaria in the south but apparently not in the north.

Anopheles excrucians, transmits malaria, but infrequently.

Culex fatigans (*Culex quinquefasciatus*), transmits dengue or break-bone fever and filiariasis; not found in Massachusetts.

The three worst pests of the Boston Metropolitan District are *Culex pipiens*, the house mosquito, *Aëdes sollicitans*, the white banded salt-marsh mosquito, and *Aëdes vexans*, the common marsh mosquito. Some of the others have been common this summer, such as *Aëdes taeniorhynchus*, the small salt-marsh mosquito.

As to their habits, we find that *Culex pipiens* breeds in any water near houses, brood after brood, from the first warm days until cold weather. Eggs are laid in water. Adult females hibernate in cellars and buildings. Short flights. Enters houses.

Culex territans has similar habits, but prefers cleaner water and seldom enters houses.

Aëdes sollicitans breeds very early (March) and continues through August or September. No regular succession of broods. Hibernates in egg stage and eggs will last more than one year. Often travels five miles and occasionally more.

Aëdes cantator has similar habits. *Aëdes taeniorhynchus* does not fly far inland. Both *Aëdes salinarius* and *Aëdes taeniorhynchus* prefer brackish waters.

Aëdes vexans winters in the egg stage at the bottom of pools, breeds early and late, chiefly in temporary puddles, frequents porches and gardens, but seldom enters houses.

Aëdes canadensis hibernates in the egg stage, hatches very early (March) and usually has but one brood a year.

Mansonia perturbans has larvae which do not go to the surface of water and which hibernate at the bottom of pools near the roots of sedges. There is but one brood a year.

Anopheles quadrimaculatus hibernates as adults in cellars and sheltered places, has successive broods, but a shorter season than *Culex pipiens*. Eager to enter houses.

Anopheles punctipennis is a short flyer, seldom found in dwellings but frequents stables, chicken-coops, and sheds.

Enough has been said, perhaps, to show that an entomological survey of the state should be made in order to give us more complete information as to the kinds of mosquitoes found and their relative abundance in different sections. The Anti-Mosquito Association of Massachusetts, through its Technical Committee, will doubtless give consideration to this matter. There ought to be a medical entomologist or a biologist learned in entomology attached to the staff of the State Department of Public Health. This department has already appointed a " Mosquito Board " from the membership of the Council and staff to study the mosquito problem and coöperate with the Association.

Drainage.

We cannot appreciate the magnitude of the problem of mosquito control unless we learn the number, size, and location of the swamp areas, as well as the ponds and pools, in which mosquitoes breed. During the summer the city engineers of the Metropolitan area were asked to send to the association local maps showing roughly the location of existing swamp areas and wet lands. The data thus obtained have been put together on a map of the District. They indicate that the problem ahead of us is a large one. At present one can only guess at the mosquito breeding areas within ten miles of the State House, but it is probably more than 10 000 acres, — say 3 500 acres of salt marsh and 7 000 acres of land wet with fresh water. The different tracts vary all the way from a fraction of an acre to several square miles.

The engineer must play an important part in the work of mosquito control. If permanent results are to be secured, hundreds of acres of wet lands must be drained. In this state we have both salt marshes and inland marshes and they require different methods of treatment. Some of the land is privately owned, some of it belongs to cities and towns, and some to the

state. The swamp areas sometimes extend across boundary lines. Engineers ought to help in this problem because they have been in a measure responsible for existing conditions. For example, a roadway is built across a salt water creek; the water above the culvert backs up, holds the flood waters and gives opportunity for *Aëdes salinarius* to breed. The railroad embankments built across the swamp areas northwest of Cambridge have created conditions favorable for mosquito breeding, and there are probably many other places where this is true. When the Charles River Basin was made and streets laid out near it in Cambridge, the low lying rectangular areas between the streets were not drained and millions of *Culex pipiens* were found breeding there in 1918. In the Charles River drainage area some of the dams are so high that the water floods vast areas, which breed mosquitoes. A reduction of the water level, if practicable, would do a world of good. I would like to see the city engineers of the various cities and towns in and near Boston brought together as a committee to suggest coöperative measures, and very likely the Anti-Mosquito Association will call upon them for advice. It might be even better for the Sanitary Section of the Boston Society of Civil Engineers to take the initiative in this matter.

In some ways the condition of the low lands near Boston is worse than in years gone by. Many areas were drained by the farmers for agricultural purposes, but when city developments drove out agriculture, the old ditches began to fill up, to cave in so that minnows and other little fish no longer swim up into them and devour mosquito larvae as they will do if given a chance. Urban conditions should be less productive of mosquitoes than rural conditions, but apparently the worst conditions of all obtain after the farmer has given up and before his farm has been fully converted into a city. As Dr. Drown used to say, with so much truth, "A state of change is a state of danger."

There are evidences, however, that drainage is again to be taken up in Massachusetts. It ought to be taken up. There is money in it; there is health in it. The state has many square miles of wet lands going to waste. Land cannot be sold by the gallon; drained swamps can be sold at a good price.

The state now has a Drainage Board (General Laws, Chap. 252, Sections 1 to 14A) composed of a member of the Department of Public Health and a member of the Department of Agriculture the function of which applies to a "meadow, swamp, marsh, beach or other low land held by several (more than two) proprietors" which it may be "necessary or useful to drain or flow" or to "remove obstructions in rivers or streams leading therefrom." On petition of the proprietors, or a majority in interest either in value or in area, the Drainage Board will make surveys, hold hearings, and, if thought advisable, authorize the formation of a local drainage district and appoint district commissioners. The commissioners are required to call a meeting of the proprietors and arrange for organizing a corporation to carry out the undertaking, if they vote to do so, under the ordinary state laws governing corporations, the proprietors being the members of the corporation, and no capital stock being required. The district drainage commissioners have charge of making the necessary improvements. The cost, which may be paid in the first instance by the county, if the county commissioners are petitioned and they so vote, is assessed on the lands benefitted through the town or towns in which such lands lie. If any part of the improvement is found by the Drainage Board to be for the benefit of the public health, the expense of that part is to be paid by the Commonwealth. After the improvements have been completed the district commissioners are retired and maintenance devolves upon the district corporation, which may assess its members. Several drainage districts are already organized or are being considered,—among them are Green Harbor, Salisbury, Weweantic (Carver), and Hering River (Wellfleet).

Malaria in Massachusetts.

Malaria is not now a common disease in Massachusetts. There have been periods, however, when it has appeared and some of the epidemics were serious. Even yellow fever was prevalent here in the early days. Accounts of these early epidemics may be found in Volume I of my book on State Sanitation. Malaria was made a reportable disease in this state in August 1914. Miss Hamblen, statistician of the State Department of Public

Health, has compiled the number of cases and deaths for the years 1915–1920. The total numbers of cases and deaths were as follows:

MALARIA STATISTICS.

Year.	Cases.	Deaths.
1915	112	6
1916	97	4
1917	78	5
1918	82	5
1919	72	4
1920	60	5
1921	49	2

Usually the number of cases has been less than 100 per year and the disease has occurred sporadically, first in one place, then another. The places in which more than ten cases of malaria have occurred in one year since 1914 are Boston, Fall River, Framingham, Newton, Dedham, Milford, Uxbridge. Between 5 and 10 cases in one year have occurred in Lynn, Natick, Wellesley, Douglas, and Northbridge. Reports of malaria were received from 76 cities and towns sometimes only a single case.

The facts show that while the malaria situation is not bad, as compared with states to the south, it is not as satisfactory as it ought to be. Massachusetts is within the upper limit of the southern mosquito zone and within the lower limit of the northern or Canadian zone. In other words, we are attacked both from the north and from the south. Anopheline mosquitoes are often found in the state. I found one only a short time ago at my house in Cambridge. Something else is necessary, however, to produce a malaria outbreak,— namely, persons in whose blood the malarial plasmodia are present. Such people are always liable to come here, either from the malarial regions of our own country or from other countries. Laborers from the pestilential marshes of southern Italy who were employed in digging the streets for a sewerage system spread malaria, and this gave rise to the now exploded theory that the disease was caused by a disturbance of the soil. Malaria is prevalent in many countries of Europe from which we have received immigration. I have been in certain parts of Roumania, near the marshes of the

Danube, where almost the entire population had or once had had the disease. Such malaria laden immigrants, coupled with the anopheles mosquito, are a menace to the public health. The proper remedy for this situation is quinine for the sick people, and oil or drainage for the mosquitoes.

We have not as yet, so far as I know, had dengue fever in this state. In the Gulf States it is now quite prevalent, and at times the disease is met with further north. Perhaps it may some time come here. Yellow fever has been here.

The hopeful thing about the situation is that these mosquito-borne diseases can be controlled, and at an expense well within the means of the people. The spectacular success of Gorgas and others at Havana, Panama, and in South America is being repeated in many places in the South and West, thanks to the well sustained work of the Rockefeller Foundation and the United States Public Health Service. It is being repeated in many foreign countries, thanks to the International Health Board and to the efforts of their own health departments. The State of Florida has done excellent work in the suppression of malaria and dengue fever, Mr. George W. Simons, the State Sanitary Engineer, being a leader. New Jersey has for many years carried on an active and, on the whole, a very successful campaign against the mosquito. The City of Providence and our town of Brookline have long waged an effective campaign, and many other places near at home might be named where suppressive measures have been carried on for a longer or shorter time.

Summary.

The Anti-Mosquito Association of Massachusetts has not yet announced its policy, but in the opinion of its president the following lines of endeavor must be followed.

1. An entomological survey of the state to determine what kinds of mosquitoes are found and when and where the different species are prevalent.

2. A sanitary survey to determine the location of the wet lands and the best methods of draining them.

3. The organization of local mosquito committees, each with a local staff in charge of a field director, co-operating with

the association, and with the territory subdivided again and again, in order that all parts may be inspected at frequent intervals by interested citizens.

4. The collection of local funds by local committees for local use in the actual work of suppression.

5. The use of the police power, if necessary, by the local health boards to secure the abolition of mosquito breeding conditions.

6. The collection by voluntary subscription of a small fund needed for the work of the association.

7. The appropriation of money by local governments for oiling and for any appropriate suppressive measures to be applied to public lands, such as streets, catch-basins and parks.

8. The appropriation by the state of money needed for suppressive measures in state lands (including the Boston Metropolitan District) expenditure to be made by the Metropolitan District Commissioner.

9. The appropriation by the State, of money necessary to provide the State Department of Public Health with a medical entomologist.

10. Persistent propaganda by the association until proper coöperation between the people, the local goverments and the state goverment has been assured.

11. A general understanding that the above measures should be pursued actively for two or three years with the expectation that if the measures succeed in reducing the mosquito nuisance efforts should be made to have the work carried on by the govermnental authorities rather than by a voluntary association.

The supression of mosquitoes more than that of most nuisances lies in the hands of the people themselves. The remedy is easy but complex. It will require the doing of many trivial things, such as picking up an old tin can, or examining the gutter of a house. There is danger of starting off vigorously and then lapsing into carelessness. There is danger lest the people be "too proud to fight." Massachusetts can get rid of her mosquito nuisance if the people are willing to take the trouble and pay the price.

DISCUSSION.

C. T. Brues.* — I have been very much interested to note the list of mosquitoes which Professor Whipple mentioned, as they were just about the same ones I had selected. It may seem to you queer we should have selected the same ones. As a matter of fact there are in this vicinity about 20 to 30 species, but those which are actually annoying can be reduced to 8 or 9, including the two malaria carrying mosquitoes, which are really numerous or dangerous. Suppose we consider these various species in three groups, as Professor Whipple suggested.

First, the *Salt Marsh* species. In Massachusetts there are only three, though further south there are quite a number.

Culex Sollicitans, which breeds in salt water and lays its eggs ordinarily just at the edge of the water. As the salt marsh dries up between the high tides the eggs become dry and ordinarily don't hatch until the succeeding year which means that the great majority hatch in June and the *Sollicitans* becomes abundant in that month and lasts for some time afterward, because at various high tides later in the season the eggs which don't hatch at first will hatch. So there is a big brood in June and then smaller broods for several weeks later. They last practically through the whole season.

Aëdes Cantator, also breeds in salt marshes under practically the same conditions as *Sollicitans,* and it is not an easy matter to tell them apart.

Culex Salinarius, breeds usually rather close to the other two, but is found most commonly in water which is almost fresh. The name *Salinarius* was given to it because it almost always occurs in salt marshes or nearby, but is always restricted to water pretty nearly fresh.

To distinguish the three kinds, the *Sollicitans* is very easily recognized. If we look carefully we find a head with large eyes each side (illustrates the following descriptions on blackboard) and a proboscis sticks out in front. On the side here are very delicate feathered feelers — *antennae.* In the male they are heavily feathered, but not in the female. It is the female that we ordinarily notice. The male keeps out of the way.

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The head is attached to the body by the thorax, and the abdomen behind is composed of a number of pieces, though it appears as one large piece. The legs are attached to the thorax and there are three pairs. As you know, the legs of the mosquito are long, composed of a number of joints terminating with a little pair of claws. Around the proboscis there is a white band. The leg joints — these little tips here — are also surrounded with white bands. On the side of the thorax is a brilliant silvery mark. Also on the abdomen there are buff bands. It is something like the yellow fever mosquito.

Cantator has not these white marks. The thorax is covered with bristles — brownish hairs. These mosquitoes migrate some distance. In New Jersey I have known them to travel for miles. Here, not quite so far.

Sollicitans I have seen in Forest Hills some miles from its breeding ground.

Salinarius doesn't go far. *Salinarius* looks very much like the two next ones — the house mosquitoes.

House Species

Culex Pipiens. — Most of the house mosquitoes are of European origin, introduced into the United States, and like all European pests are very abundant and annoying.

Culex Territans.—Is very similar in habits and appearance. So we have these three looking very much alike. *Salinarius* breeds near salt marshes and is particularly common in summer resorts as along the South and North Shores.

Pipiens we find practically everywhere, breeding in dirty water. Most mosquitoes like clean water, but *Pipiens* prefer dirty water with a good deal of odor and a large amount of decaying organic matter. *Territans* is similar but prefers cleaner water.

Those three species have no band on the proboscis. They have bands on the taussi, which however are very inconspicuous, and the abdominal marks are much fainter. Rather nondescript mosquitoes are apt to be these.

Salinarius is found along the coast and the larvae of those one looks for on the edge of salt marshes. I have noticed frequently the presence of *Salinarius* due to the building of a road where some of the salt marsh has been cut off from the ocean and has resulted in the water on that side becoming fresher than when the tide had access. And these other two occur further back from the coast practically everywhere.

Now in addition to the house species we might perhaps include two species of *Anopheles*. There are various species of *Anopheles* throughout the world and they carry malarial fever of various kinds. We have here two species. One is the *Anopheles Punctipennis*, which is rather common and does not carry malaria in the north, so far as we know. And there is one which cannot be distinguished from it which carries Tertian malaria in the South. We never find malaria in Massachusetts where only the *Punctipennis* is present. *Anopheles Quadrimaculatus* is the one we commonly have here. In the *Anophelines* the structure of the body is quite different. They are very easily recognized. The females have a beak and on either side a short pair of appendages between the feelers and the beak. These are the palpi. They are very short — almost indistinguishable — in other mosquitoes, but in the *Anophelines* they are long. The males don't come close to people. They keep out of the way. So there are three things sticking out at the head, instead of a single projection as in the other forms. The two kinds of *Anopheles* can be distinguished, but not readily.

The wing of a mosquito is quite narrow and rather long. It is attached at the thorax. All of these other forms have the wings, with a number of veins as you know, which are covered with minute scales of a brownish or dark color, so that the wings are not transparent but are uniform in appearance. In all *Anophelines* there are spots which extend beyond the dark scales on the veins. The *Anopheles Quadrimaculatus* has four dark spots and practically no light spots. The *Punctipennis* spotting is more regular and most noticeable for two dark and two lighter spots along each of the wings. Any spotted wing mosquito in Massachusetts is an *Anopheles*. The smaller form, *Quadrimaculatus* has only four distinct dark spots and no light spots and

this is the one to look out for as it actually carried malaria. The markings on the legs — the bands — are not so very conspicuous. The best way to distinguish them is by the wings. Those are the ones which ordinarily bother us in the house and on the beach and piazza, in the yard, etc.

On farms and in woodlands there are other forms, a few of which Prof. Whipple has mentioned — the same which I had thought most common from my own experience.

First, Aëdes Silvestris, or *Canadensis*. There are a good many others and it is rather hard to pick out the most abundant. Everyone knows certain places where one species is more common than the others. Right around Boston there are six or eight species which seem to be numerous enough to be annoying although usually one or the other of these two are present. *Canadensis* appears earlier in the season, and more or less disappears later. It over-winters in the egg stage, goes through larvae development and becomes fully developed when the marshes are flooded, which results in a rapid development of the larvae when the eggs become wet in the spring.

Sylvestris broods follow one another and the species becomes more common in the late summer. They, too, select places where there is water. Consequently we find them in areas where we think it is quite dry, because the mosquitoes have had their brood there earlier when the place was flooded. One of the best indications if you are not present when the mosquitoes are breeding is a study of the vegetation, as an index as to where to find the mosquitoes. In many of these places if, for example, we could examine the vegetation later in the season after some of these areas have dried up, it is practicable by the grasses and sedges to get an index of where the mosquitoes came from. I am afraid I have not given a very clear account of the species, but as a matter of fact some of them it is almost impossible to distinguish without a rather powerful hand lense, and there are so many of them it is ordinarily most convenient to refer to a key of some kind.

If I could have a moment more I would like to say just a word about the larvae.

They are extremely interesting. I prefer collecting them and identifying them rather than the mosquito. The character is more easily seen. They live in water, having a projective breathing tube. The body hangs down in the water and the head is at the bottom, so we have this siphon at the posterior end sticking through the water and getting air for the mosquito to breathe. This siphon is sometimes very long. In the *Culex Pipiens* it is very long and narrow, and in most *Aëdes* it is very short and perhaps somewhat swollen in the center, like this (illustrates). In the *Culex* there is a little series of bristles here (illustrates). *Salinarius*, *Pipiens*, *Territans*, *Restinans* are very similar in these characteristics. *Aëdes* have a series of comb like bristles at the base of the tube, and *Aëdes* and *Culex* are distinguished readily, only in the larvae stage, by a brush of bristles and the short stiff bristle. The *Anopheles* breathing tube is very short and consequently the body lies more or less flat on the water, with the head close to the surface and the stellate hairs come out about half way down on the body and help keep the larva on the surface. The *Anophelines* rest near the surface and the *Culex* hang down.

The pupae remain at the surface of the water if they are not disturbed. They are of rather peculiar shape with head, thorax and abdomen rather small and a pair of horns projecting from the middle part of the body for air. The larvae are commonly seen wiggling around in the water. If the water is disturbed they usually go to the bottom and hide in the mud or dirt. They will hide for a while and then come to the surface again and thrust their tubes through to breathe.

If anyone has any question I will be glad to answer them. I don't know so very much about the mosquitoes around Boston, because I have not studied them except in a few areas particularly north of Boston and around Dedham. Professor Brues in reply to questions continued:

In the ordinary summer temperature I think the average length of a generation of the mosquito might be about three weeks. That is to say, it would be less from the egg to the adult, but it is necessary for the adult after it hatches to remain a few days in the feed before the eggs mature. Ordinarily a generation

develops in ten days and probably it is another week or ten days before another brood is produced, so the number of broods is not so great as might be supposed. In cooler weather they grow more slowly. In the spring and fall they grow very slowly. The growth corresponds to variation in temperature.

The range of temperature under which they develop varies with the different forms. Some come out early in the spring. Some breed in melting snow in very cold weather. Many appear in March and April. They are quite common the latter part of April. *Anopheles* develops very slowly in the early part of the season, and hardly comes here until September. There is only one noticeable brood of those. They come in the rather late summer.

Mosquitoes breed in catch basins, in fact catch basins have been devised to contain a film of oil to prevent mosquitoes breeding. By a *siphonic* arrangement by which the water is drawn off at the bottom, a film of oil is kept all the time on the surface of the water. It is quite an annoying feature in many cities, the catch basin breeding spots.

The oil is just poured in, or preferably sprayed. Preferably, a very light oil is used because it is not carried down so readily with the water and comes more quickly to the surface. Kerosene is usually preferred.

As to what the mosquitoes feed on in the woods where there are no people, that is a very puzzling thing because commonly the mosquito cannot fertilize her eggs without blood. We think they must get it from birds, probably mostly at night when they are roosting. Possibly also from reptiles, but mainly from birds. I wouldn't dare to say so before the Audubon Society, because it seems rather radical to get rid of the birds in order to get rid of mosquitoes. They undoubtedly do get a good deal of blood from birds.

If the salt marshes were drained and minnows let in that would be very effective, especially the top-minnow. Where there is a pool with those minnows there are no mosquitoes and no pupae. They don't get the larvae so well, but of course if they get the pupae it is the same thing. I have often found larvae but not the pupae. That is one of the most efficient natural

means of controlling mosquitoes. In fresh water gold fish are used as they are very fond of mosquito larvae. In the tropics in many places it is possible to keep the larvae under control by means of gold fish.

The question is asked as to whether the organism of malaria and yellow fever can be carried in the bodies of birds and other warm blooded animals?

Yellow fever is peculiar to the human species, although it has recently been said it could be transmitted to apes. Also supposed organisms can be recovered from animals like guinea pigs, though they show no symptoms except a slight rise in temperature. Only one type of mosquito carries yellow fever. In the case of malaria there are several species of *anopheles* — some carry one kind and some another. Some carry the disease much more rapidly than others, as it is necessary to develop the organisms in cysts in the stomach. So there is a very considerable variation. Mosquitoes never carry the malarial organisms over the winter, however. They are never infectious. in the spring, but only from chronic cases of malaria. That is why we have malaria common in the southern states and even in the central parts of the United States when we don't have yellow fever, because it dies out as there are no chronic cases of yellow fever but it has to be brought in and comes in the form of epidemics.

Vol. IX DECEMBER, 1922 No. 10

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

DEVELOPMENT OF THE LIGHTER-THAN-AIR AIRSHIP.

BY EDWARD SCHILDHAUER.*

(Presented before The Affiliated Technical Societies of Boston, November 23, 1922.)

BEFORE the advent of aerial transportation the modes of travel were restricted by the extent of land and of water area. Railroad systems and shipping lines, alike, must terminate at the seaboard, where transfer may be made from one to the other. The airship, on the contrary, since it takes as its pathway the air, has no such limitations. It may establish its port in an inland city, should the facilities there seem superior to those on the coast, or in a seaboard town, which is usually preferable. It is of advantage that the port be made a combination of airship and airplane harbor, for it is the belief of those who have studied aerial navigation that the time will soon come when the lighter-than-air and the heavier-than-air craft will together afford the principal means of high-class transportation. The port should be located as closely as possible to the business center and be easily accessible to surface transportation, as is the case at McCook Field, Dayton, Ohio, which is within eight minutes of the center of activities.

From a study of probable future developments in airship transportation in America it appears that Chicago is the most favorable location for a main harbor, not only in view of present transportation facilities, but also from the standpoint of na-

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tional defense. While Chicago has made a start toward the establishment of an airport, like other cities, she is finding it difficult to impress upon the public the great benefits to be derived by the nation first to enter the field of development of aerial transportation, and similarly that those cities favorably located for aerial ports, if they will take early advantage of such a development are certain to benefit largely. In spite of some disadvantages, it is quite within the realm of possibility that Boston should become the preëminent airport in America, if the project is carried through in a comprehensive manner.

Whereas theoretically the route of an airship between two cities may be a straight line, economically the most direct route may not always be the most advantageous. For instance the shortest route between Chicago and London would pass over the southern portion of Labrador and a few degrees south of Greenland — a total distance of about 3 800 miles. By making a detour of but 180 miles the profitable ports of New York and Boston could be included. Similarly, in going west from Chicago, the shortest routing to Tokyo would pass over the central portion of Alaska, thence to Kamchatka and from there follow the group of islands to Tokyo — a distance of about 6 000 miles; whereas if the route were extended but 180 miles it would take in Seattle. From Chicago to Moscow the shortest route would be approximately 4 800 miles, passing over the northern part of Labrador, the central portion of Greenland and Norway, over Petrograd and thence southeast to Moscow. Stefanson, the explorer, assures us that airship routes crossing the arctic circle are perfectly feasible.

Of course, all of these routings must be varied slightly from season to season and from day to day, subject to the direction and the speed of the air currents.

European airship development has progressed, within the last decade from a very crude beginning, through a series of improvements, to an accomplishment whereby passengers may be transported safely over long distances and according to a predetermined schedule. It is a fact that of the thousands of passengers transported in passenger airships in Europe, not a single casualty has occurred.

Airships may be constructed on the principle of non-rigid, semi-rigid and rigid. The so-called "Blimp" is a non-rigid device and commonly has a cubature of about 5 000 cubic meters. With the semi-rigid airship there is a practical limit in size of about 30 000 cubic meters, though the Parseval has attained 31 000. This type is provided with a metallic girder to which the fabric of the hull is attached above, while below the gondola or nacelle is suspended. The Italians have had a certain amount of success with the semi-rigid ship and sold to the United States Government, at a time when the rate of exchange was favorable to us, one of a cubature of about 34 000 cubic meters. This airship was wrecked, killing some of the ablest airship personnel of our Army.

For practical purposes it may be considered that the total lift of an airship is equivalent to one thousand kilograms or one metric ton per one thousand cubic meters. Therefore the "Blimp" above mentioned, would have a total lift of about five tons.

Development in Germany.

In 1897 an airship was constructed of which the fabric covering was replaced by metal reinforced to make the structure rigid. It was inflated but did not perform a successful trip. Meanwhile Count Zeppelin was experimenting with rigid airships and in 1900 he brought out his first type — a very crude affair as compared with the airship of today. This was a long cylindrical ship with rounded ends, equipped with 32 h.p. motors. Maneuvering in the vertical direction was accomplished by manipulating a weight suspended from a slack line fastened to the front and rear of the ship, so that the center of gravity of the airship was altered, thereby inclining the ship either up or down as desired.

In 1905 the third airship was constructed another long cylindrical affair with the keel covered and vertical rudders.

During the following years various ships were designed and experimented upon, until in 1908 one was constructed which attained a duration flight of 20 hours. This ship was similar to the 1905 type, but had more extensive rudders. It was

forced to land owing to motor trouble and while the motors were being repaired a severe storm arose, the ship was torn from its mooring and wrecked. From that time until 1913 the ships constructed all had external keels and side propellers driven through the shafts from the nacelle swung from beneath the keel.

The LZ-18, or L2, of the Navy, however, by order of the Navy Department, was equipped with the interior keel and gangway, the room in this keel being utilized for the storage of fuel, ballast, goods, etc. On a trial trip with members of the Department on board, the ship burned and the entire personnel lost their lives. It was the practice of the Zeppelin Company to discharge the hydrogen into the hull structure, as a consequence of which there would be a mixture of hydrogen and air. In other words, the gas bags full of hydrogen (which in itself is non-explosive) were surrounded with an explosive mixture of hydrogen and air which condition obtained until the mixture had percolated through the hull fabric. The wreck was attributed to the fact that the airship was fully inflated when on the ground and as it rose the gas expanded, due to decrease in pressure of the atmosphere, and the automatic valves opened to discharge the hydrogen. The ascent was so rapid that the explosive mixture between the hull fabric and the gas bags could not dissipate fast enough through the fabric of the outer hull and therefore sought the manhole openings between the power plant and the interior gangway, thus coming into contact with the engine exhaust, which resulted in the explosion. This wreck occurred in November, 1913. On account of it the Zeppelin Company reverted to the exterior keel construction. In 1915, however, they again returned to the interior gangway and keel and have followed this construction to the present time.

The first Zeppelin airships were made of aluminum profiles, but after 1915 duraluminum was employed extensively. In the early airships, also, the outer fabric was wound circumferentially, whereas in later designs the fabric is laid on horizontally and tied to each other over the horizontal girders, the covering strap being placed over the tie string. This change has resulted in reduced resistance of the ship and thereby a gain in speed.

In the fall of 1908, as the financial resources of the Zeppelins were at an end, the German people donated a total of about six million marks, which amount was used for further experiments and is the foundation for the present Zeppelin activities. Shortly after this fund became available ships were built for commercial purposes.

The twelfth ship designed for the Navy was of 31 900 cubic meters, with operating nacelle in the rear, equipped with engine capacity to drive one propeller direct, and two side propellers driven by means of the typical early Zeppelin drive-shaft. In this form the box type of rudder gave place to plane surface rudders and stabilizers.

In the development of 1916 (the L-30) the commander's nacelle is again extended and the power plant is immediately annexed. The rear nacelle is as in the type just described, but in addition there are two power nacelles amidship, with direct driven propellers. The outline of this airship approached a stream-line. There were in all ten of this type of ship built.

In 1917 the L-40 was built, also with a cubature of 55 000 cubic meters. Sixteen ships of this type were constructed.

The next development was the disappearance of the side drive shafts from the rear nacelle. A ship of this type came to grief in France, on its return trip from England, and was studied and dissected by the French.

Another ship originally of 55 000 cubature, but which had been increased to 68 500 cubic meters by the insertion of thirty meters amidship, is the L-57, which was especially constructed for the South African trip. It had to be abandoned for this use, however, for on the trial trip an inexperienced pilot made a heavy landing, seriously injuring it. Within two weeks the second ship, L-59, which was part of the program, was finished and finally made the trip from Jambol, Bulgaria, across the Mediterranean Sea and Egypt, to a point west of Khartum, where it received word that the German garrison had surrendered, and was ordered home. The total lapse of time was a little over 95 hours and the total distance covered about 4 500 miles. Previously a ship of much smaller dimensions had been on patrol duty over the Baltic Sea for a period of 104 hours.

The airship of today is divided into from 15 to 19 gas compartments, at the end of each of which there is a main ring stiffened by diagonal wires. In order to strengthen the longitudinal girders which extend the whole length of the ship two intermediate rings are inserted, which are not reinforced by diagonal wires. Wires are also strung between the horizontal girders, forming the net which retains the gas bag in its proper position. Through them and through the girders the lifting power of the gas is transmitted to the hull.

The most recent development in passenger airships has been made in Germany in the "Bodensee", which made her initial trip on August 24, 1919, and her last trip in Germany on December 1, 1919, for in 1921 she was delivered to Italy and at the same time a sister ship to France. The "Bodensee" has three power nacelles, a central propeller driven by two 260 h.p. engines, and side cars with one engine each of 260 h.p., giving a total horse power of 1 040. This means a speed of 80 miles an hour for a ship of 22 500 cubic meters and a total lift of 22.5 tons, of which 45 per cent. is useful or disposable lift. As a ship is increased in size the disposable lift increases more rapidly than the total lift. Therefore it may be said that the efficiency of a ship increases as the size increases. The "Bodensee" accommodates about 24 passengers and has transported between Berlin and Friedrichshafen 2 380 passengers in a total operating time of 101 days. It has demonstrated that it is practicable for a ship carrying only about 20 or 24 persons to maintain a predetermined schedule. Whether an airship is designed to carry 20 or 100 passengers, however, the general outline remains the same, the only difference being in the cubature and the possible addition of power nacelles. The recent ships are very roomy and are equipped with wireless so that they may be in communication with predetermined stations at all times, receiving weather reports, news items, etc.

In the years 1908 to 1911 there was a competitor of the Zeppelin Company, in the person of Dr. Schuette, Professor of Naval Architecture and an engineer for the North-German Lloyd. Through his efforts the Schuette-Lanz Company was formed.

Calculations and experiments showed that ply-wood was stronger per unit of weight, than aluminum. All of the Schuette-Lanz ships therefore were made of ply-wood. The first ship constructed had serpentine girders which when assembled appeared as a series of helices. The depressions in the surface of the hull fabric interfered greatly with the speed of the ship and consequently this type was abandoned. In later types strips of cotton fabric are secured to the horizontal girders by twine and strips are glued to the fabric, to cover the twine, thus presenting a smooth surface to the action of the air. This early ship, above mentioned, had suspended nacelles with direct-driven three-wing metal propellers, a stabilizer in the front of the ship, another beneath the hull just back of the propeller, and plane surface stabilizers and steering vanes.

After several trial trips the ship was remodeled by the removal of the small front and rear stabilizers and the installation of full cross stabilizers at the tail, together with plane surface rudders. The power units were relocated to give better balance. This ship made many successful trial trips but had to come down in an open field on account of engine trouble, and while the repairs were being made a storm tore up the anchorage and the ship was wrecked.

The second ship produced by the Schuette-Lanz Company, in 1912–14, had an inside keel and gangway, direct drive of the propellers from the power units, gas shafts for the elimination of hydrogen gas (between each pair of gas bags, extending through the top of the hull) and horizontal girders instead of serpentine. It also had a central wire running from stem to stern in the center of the rings. This wire served the purpose of holding the center of the diagonal wires from the main rings, so that the gas pressure, should the ballonet be empty, would be everted against the network of only one-half the diameter, thereby decreasing the strain on the particular main rings affected. The rings were fabricated in a horizontal or flat position. In order to raise them to the vertical a triangular false work was employed. The main ring is secured to the triangle at three points and all the strains of handling are transmitted through this triangular frame.

All airships of the rigid type are equipped with water ballast contained in bags suspended from the keel. The discharge of this ballast is controlled from the commander's nacelle. Some of the forward and aft ballast bags are equipped with emergency trip so that the contents of the bag, about one ton of water, may be released instantly.

The power units are suspended by means of wire ropes and struts. These struts, however, are inferior in strength to the member to which they are fastened to the hull, so that in case of heavy landing, they will break instead of injuring the airship structure.

The characteristics of the second airship produced by the Schuette-Lanz Company, above described, have remained through the twenty ships produced by them, with the exception that whereas the second ship had a cubature of about 19 000 cubic meters the last has 56 000 cubic meters.

The Zeppelin Company has put out a total of 115 ships, 88 of which were built during the war period, 25 before the war, and 2 since. The Schuette-Lanz Company delivered a total of 16 ships to the German Government, two of them before the war. The principal difference between the ships of the two companies at the present time is that the Schuette-Lanz Company adheres to the idea of having the commander's nacelle separate from the power units, while in the Zeppelins the commander's nacelle and power unit are combined. The Schuette-Lanz arrangements were adopted, however, by the Zeppelin Company in 1919, in the construction of the "Bodensee," in which the commander's quarters are in the forward part of the nacelle for passengers, and the 3 power units are suspended aft. The developments of the two rigid airship companies of Germany have now merged, and it requires an expert on detail to distinguish the Zeppelin from the Schuette-Lanz ship.

British Development.

The British method of erecting an airship is different from the German in that they build the rings in a horizontal position and attach thereto a portion of the horizontal girders in a vertical position. The structure is then handled by means of block

and falls, with a slip noose, so that it can be transferred from a vertical to a horizontal position.

Rigid airship design and construction was started in Great Britain about 1909, and the first ship underwent so many changes and "improvements" that after it was filled with gas and launched in May, 1911, the "May-fly," as it was popularly called, did not fly — it was too heavy. This, however, did not deter them from continuing the development with ultimate success. In 1917 a ship of Class 23 was launched — a cylindrical affair with pointed ends and external keel, following the lines of the early Zeppelin, the power units being suspended beneath the keel and the propellers direct-driven. The three propellers were in line and consequently in each other's slip stream. A fighting airplane was successfully carried and released from this ship, though no successful return to the airship was reported.

In December, 1916, the German airship L-33 was shot down at Colchester, England, which showed stream line construction and suspended nacelles of the Schuette-Lanz type. From this and later captures the airship known as R-33 and R-34 was evolved. Also the British have adopted the Zeppelin method of combining the forward power units with the commander's nacelle. The balonnets are at present made either of silk or cotton fabric, covered with gold-beater's skin.

It was in the R-34 type that the Trans-Atlantic trip of 1919 was made, reaching Mineola, Long Island, after 108 hours in the air. The return trip was made in 75 hours.

Aerial Development in America.

For American conditions a larger capacity of ship will be necessary, such as one of 150 000 cubic meters, which would be capable of carrying 100 passengers and 80 tons of express matter from Boston to Chicago overnight. In order to put America first in the air, the night-flying should be done by airships and the schedule so arranged that the landing will be early in the morning. In fact, were it not for the night-flying capabilities of the airships, they might not be able to compete with railroad and airplane transportation, but the maneuvering of an airship

at night is not as nerve-racking as by day where it must pass through alternate spaces of sun and cloud. Safe night-flying by airplanes has not yet been achieved, but it has been successfully accomplished by the airship. From the same field airplanes may take individual passengers or small groups of passengers to the outlying cities within a radius of 200 to 250 miles,

FIG. 1 — DESIGN FOR A DINING-SALOON FOR A 100 PASSENGER AIRSHIP.

reaching their destination during the daylight hours, and also may carry high-class express matter and mail, leaving to the airships the longer passenger lines which would mean night travel.

The equipment of a modern up-to-date airship approaches in luxury that of a first-class ocean liner. The illustration, Fig. 1, shows a draftsman's conception of the dining-saloon of 100 passenger airship capable of making trips to South America. The ship would have a capacity of 200 000 cubic meters, a length

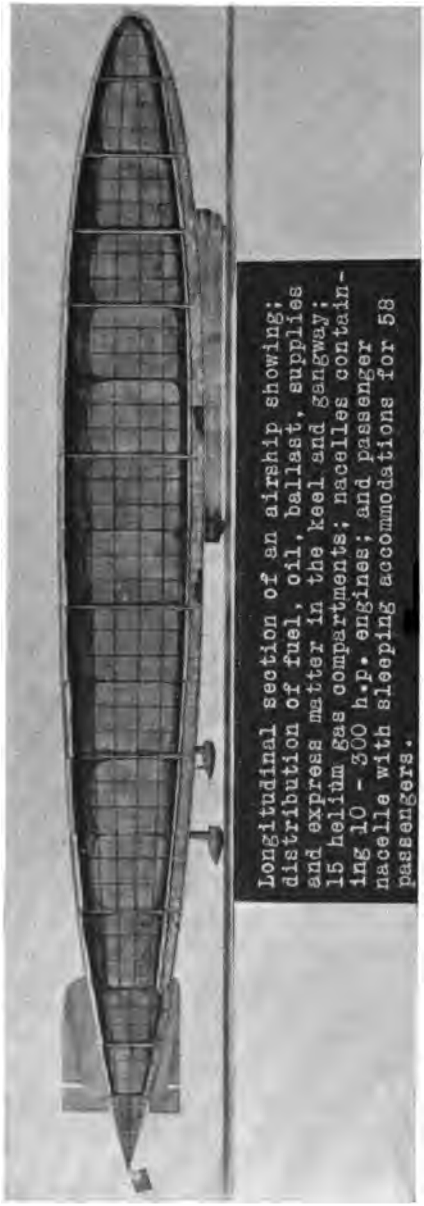
Longitudinal section of an airship showing:
distribution of fuel, oil, ballast, supplies
and express matter in the keel and gangway;
15 helium gas compartments; nacelles contain-
ing 10 - 300 h.p. engines; and passenger
nacelle with sleeping accommodations for 58
passengers.

FIG. 2.

of 975 ft. and a total horse power of 5 400. This would admit of a promenade deck 225 ft. long, sleeping accommodations as luxurious as those in the most elaborately equipped ocean liner, dining room, salon, etc. The hangar necessary for such a ship

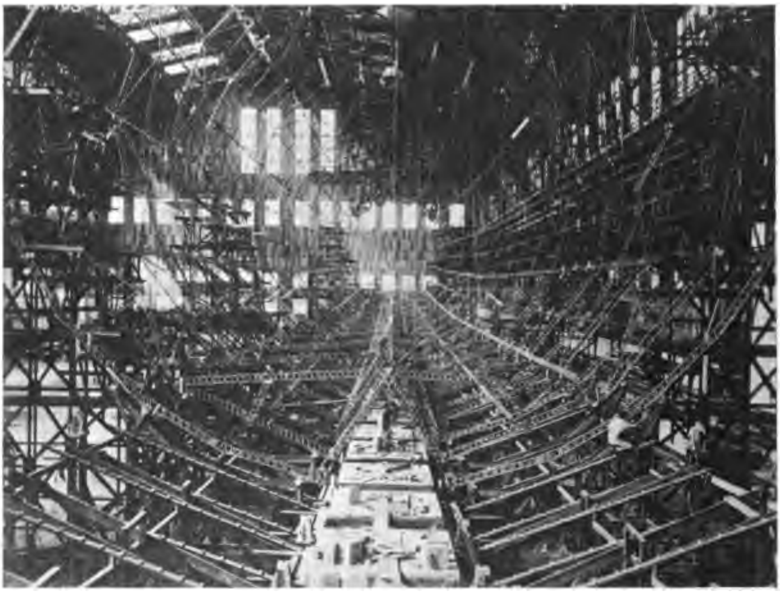

FIG. 3 — ASSEMBLY OF AIRSHIP ZRI AT THE U. S. NAVAL AIR STATION, LAKEHURST, N. J.
(Official Photograph U. S. Navy.)

would be approximately 160 ft. wide, 1 050 ft. long and 160 ft. high. Figs. 2, 3 and 4 illustrate some of the construction details of an airship.

THE AIRPORT.

As already mentioned, it is of advantage to have the airport as near as possible to the center of activities and readily accessible to other transportation lines, so that transfer of passengers and express matter may be facilitated. The total area of such a port should be at least 100 acres, although the necessary landing field with mooring mast, hangars, and gasometers

will probably not occupy the whole of this land. The 100 acres should nevertheless be kept under the control of the airship authorities, even though the greater portion of it be utilized for the cultivation of cereals, or in some such way. Scott Field at Belleville, Ill., not far from St. Louis, is an excellent example of an airship harbor, and is the center of activities for the lighter-than-air branch of the Army Air Service. The hangar here

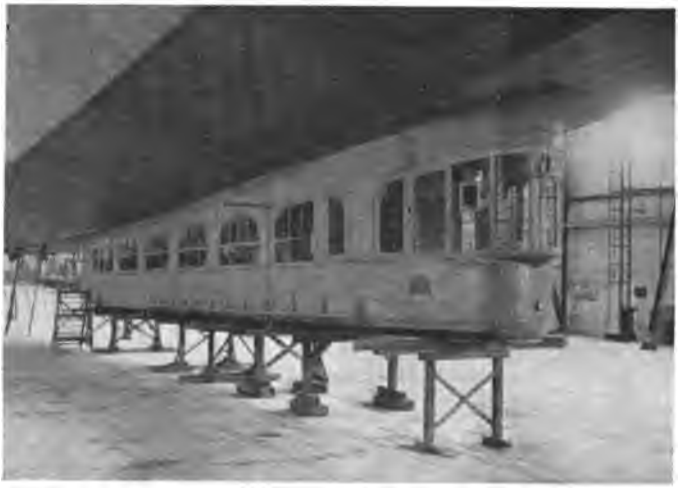

FIG. 4 — TYPICAL AIRSHIP NACELLE FOR 24 PASSENGERS, COMMANDER, NAVIGATORS AND WIRELESS OPERATOR.

is 800 ft. long, 150 ft. wide and 150 ft. high, in inside dimensions. The largest hangar in the world is at Lakehurst, N. J., and was designed in our Navy Department. At this field, also, is the mooring mast shown in Fig. 5. When a ship wishes to land at this mast it maneuvers to about five or six hundred feet from the ground and then drops a mooring line from the nose of the ship. This is coupled to the line which is strung through the center of the mooring tower and through the center of the mooring cone, and is laid on the ground to leeward. After these lines are secured the airship is permitted to rise to equilibrum where the commander trims the ship, making it a little

nose-light.. Then, on signal from the commander the winches are started, the ship is hauled into the mast and when it touches, the cone is locked, the total time required for these operations varies from 10 to 15 minutes. After this the gas, oil and water lines are attached to the airship and whatever it is necessary

FIG. 5—AIRSHIP MOORING MAST AT U. S. NAVAL AIR STATION, LAKEHURST, N. J.

(Official Photograph U. S. Navy.)

to take on board is moved in this way. While the ship is at the mast only a few officers and men are necessary to maintain proper equilibrium. The mast shown has the most up-to-date equipment, including mast elevator so that passengers and airship personnel can make the journey of 150 or 160 ft. to and from the ground without climbing. To release the airship it is only necessary to weigh it off properly and withdraw a bolt which opens the cone holding the ship in position.

Boston is well situated for an eastern terminus, as the manufacturing towns of high-grade articles are within easy reach by means of airplanes. As a national center, however, Boston or any of the Atlantic coast cities are not as well situated as the metropolis of the middle west, Chicago. Therefore, in order that Boston may reap the benefits of aerial transportation it should start at the earliest possible moment to lay out a harbor on a comprehensive scale, and induce aircraft companies to utilize the field, so that aerial transportation will be established in the early stages before competitive inducements are offered by other coastal cities. In the consideration of an airport it is necessary that weight be given not only to its accessibility, but also to its availability for all three classes of aerial transportation — seaplanes, airplanes and airships, in order that it may afford a combined or " Union " port. With these requirements in mind the development on the harbor front in Boston appears to offer a splendid location for an airport.

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

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COMMERCIAL USE OF AIRPLANES.

BY EDWARD P. WARNER.*

(Presented before The Affiliated Technical Societies of Boston, November 23, 1922.)

THE lighter- and the heavier-than- air craft both have their uses in commercial transport, but those uses lie in different spheres. Mr. Schildhauer has set forth the position of the airship, which is peculiarly fitted for journeys over long distances at relatively moderate speeds, moderate at least as compared with the maximum attained by the airplane. The other type, the airplane, is particularly designed and suited for transport over much shorter distances at very much higher speeds.

Commercial aerial transport as we understand it today dates from August 26, 1919, when the London to Paris route was opened. To be sure, there had been various attempts to carry passengers and freight before, but these projects had been small in extent and had lasted relatively for short periods and they were not operated on a basis which we can now consider as truly commercial.

I shall not weary you by undertaking to sketch the history of the development of the airplane through the three years before the opening of the London-Paris route and up to the present time. The development has been too great, too extensive and continuous for me to attempt even to give the briefest outline

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in the whole time allotted for my talk tonight. I want to turn then at once to the present position of aerial transport in Europe and America and to speak briefly of some of the problems which those who are seeking to use the airplane for commercial purposes have had to meet.

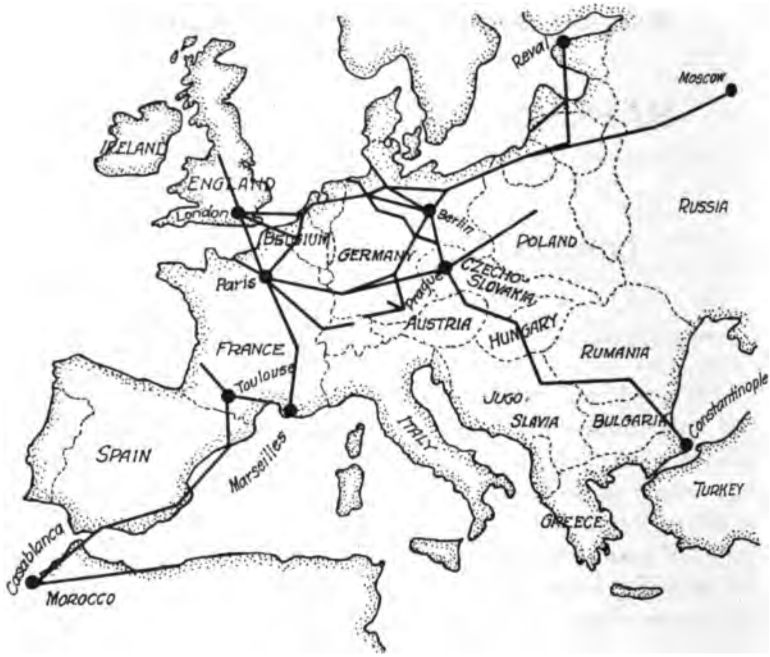

FIG. 1 — AIR LINES OF EUROPE.

(Fig. 1). This map shows the air lines of Europe, as they are now, and it will be observed that there is reasonably direct connection between most of the European capitals. For example, one line runs direct from Paris to Constantinople, with stops at the Central Europe capitals. You can go by airplane from Paris to Constantinople in 2½ days, whereas it takes 4 days by express train. There are a great many lines in Germany, and there is a line operated by German capitalists in coöperation with the Soviet Government, from Königsberg to Moscow. That is the most interesting line in Europe in some respects.

The journey is done by train in five days and nights from Berlin to Moscow. The air journey from Königsberg to Moscow is done in 12 hours. A night train from Berlin to Königsberg makes the total time from Berlin to Moscow 24 hours. The line is very extensively patronized by diplomats and Soviet officials.

As another illustration as to what can be done in the saving of time I will cite an experience of my own. On August 4 last I had breakfast in Vienna, left the hotel at 7.30 A.M., and took an airplane for Paris. With two changes of plane and pilot, at Prague and Strasbourg, we reached Paris at 8.30 that night, in 8 hours and 47 minutes actual flying time. By fast express the time from Vienna to Paris is 32 hours — giving a saving of about 65 per cent. by air.

That gives a very slight idea of the present status of air transport in Europe. There are scheduled for service in France next summer air routes covering nearly 7 000 miles a day. In Germany there are about 2 400 miles of regular daily passenger services.

Although I am on the program to speak on European Commercial Aviation I should not feel I had done justice to the subject — to the commercial use of the airplane — if I did not touch on commercial flying in the United States. We are, I think, in this country under the impression — spread by magazine articles — that the Europeans are far ahead of us in the commercial development of the use of the airplane. That is true to a certain extent. They have developed it in a way in which we have not developed it here. For example, there is only one passenger air line in the United States at the present time — or rather one in summer and one in winter, operated bv the same company. There is, however, notwithstanding the sparsity of passenger development, more actual commercial flying in the United States, measured by airplane miles, than in any single country in Europe. During the past year the total distance covered in France by commercial lines was approximately 1 300 000 miles. The total distance flown by the United States Air Mail in the regular pursuance of its work, carrying mail every day both ways between New York and San Francisco, was 1 800 000 miles, and they flew their route with 96 per cent. perfect per-

formance through several months — a performance of over 90 per cent. over the whole year. They met all kinds of obstacles — terrible weather conditions, machines getting caked with ice, ice accumulating on the propeller, and the pilots sometimes having to fly only 15 or 20 ft. above the railroad tracks to find their way. Nevertheless they have kept going without a single fatality for over a year. I think we are prone to be too pessimistic with regard to commercial aviation in this country, and do not realize the extent of the work already being done here.

If we turn from the present status of flying to the restrictions laid upon it and to the conditions under which it works, we find the problems to be confronted can be divided into three classes — legal, economic and technical. With regard to the legal questions I shall say nothing. It is a very complex subject and I have not time to take it up now. To the two other classes, however, I will devote some attention. It might perhaps be better to pay particular regard to the technical questions before this audience, but the economic problems are absolutely fundamental. Airplanes may be operated under conditions of inefficiency, improper conditions as regards equipment, even dangerous conditions, but no private concern will continue to operate a line on which it is losing money. So we come to the question — how much does it cost to run an airplane? That is the first thing to be settled, but the answer cannot be given in a few words. It depends upon the type of airplane and the conditions under which it is operated. As a round figure, however, we may say the cost of operation with present day machines will be from 12 to 15 cents a passenger-mile, with airplanes of the type now available, assuming they are carrying a full load. Allowing 15 cents a passenger-mile, and allowing the usual amount of baggage, bringing the total weight to 200 lb. per passenger — would bring the cost to $1.50 a ton-mile, which works out at about 50 cents a pound for express between New York and Chicago. On this 50 cent per pound express rate several companies are now basing plans for airplane lines between New York and Chicago. The unit cost of operation can in general be decreased by the use of large planes,

but of course the companies cannot afford to put on the large planes until they are assured sufficient load to warrant them. They have to start with small planes and with a high unit cost until the public has shown a willingness to patronize the line sufficiently to warrant the use of large planes. I think, however, that with the development we can foresee in the next few years and with that increase in public patronage which we hope will come after the lines have been operating for a while we may confidently expect a reduction in the operating cost to about 80 cents per ton-mile. The present cost per air-mile by Air Mail, which has kept exact figures, is a little over $1 per airplane-mile including all overhead. The ton-mile rate is very unfair for comparison there, because the Air Mail machines, originally taken over from the Army, do not carry anywhere near the pay load that should be carried with their engines. The body is not big enough to store it. With the same engine, with re-design of the cargo space, it ought to be possible to carry nearly three times the pay load now carried and, with modified wings to carry a pay load of about 1 600 lb. — which allowing $1.10 an airplane-mile would work out about $1.50 per ton-mile.

Having gained some idea as to costs of operation to the operating company the next question that logically arises has to do with the present charges for air transport. There are a lot of lines running in Europe, several which have been going for more than three years and have increased their service. For example, the line from Toulouse to Casablanca and Rabat has been running an airplane every day except Sunday over a 2 000-mile route during the past year, having started three years ago with three airplanes a week. Evidently there is some economic incentive to continue the service. Present passenger fares on air lines in Europe — not counting Germany and the other Central European states because theirs is a peculiar problem — runs from 8 to 13 cents a passenger-mile. The maximum is about the figure I set for the cost of operation, and the minimum is considerably below that. The cost of the cross-channel service, on which a great many Americans have travelled, is 13 cents a passenger-mile. That will probably

be reduced next summer. From London to Paris or Amsterdam, when I was there the rate was 6 guineas — roughly \$28. During the past month the London-Amsterdam rate was reduced to 4 pounds, or \$17.50 — from 13 cents to about 8 cents a passenger-mile. Eight cents a passenger-mile is the uniform rate in France.

In Germany conditions are different, no less so in connection with air transport than in every other particular. I haven't the latest figures on the cost of air transport in Germany, but when I was there last July one could go by air from Berlin to Hamburg for \$3.50 — a little less than 2 cents a passenger-mile. That is typical of the fares all over Germany.

You will note that there is a considerable hiatus between what I have given as the fares and what I have given as the operating costs. As to the method by which that hiatus is at present filled, I will postpone discussion for a moment, because before we can realize the full extent of the gap, the extent to which it has to be dealt with, we have to know something of the amount of travel on the air lines, the amount of business they are doing.

Fifteen cents a passenger-mile to operate and 13 cents a passenger-mile as the fare, doesn't mean much. It may be more profitable, in fact it was found so on the London-Paris route, to run at 13 cents than to run at 25 cents, because it was easier to get passengers and cutting the fare in half more than doubled the traffic. During the past two summers the planes on that route have been very well filled. If you want to know the record in respect to traffic, to show the very best of what has been done, it is to the London-Paris line that you must turn first of all, because, for various reasons, that line has outpaced all others as regards the business done. I have brought with me the exact figures for a short period last summer, during the last three weeks of August and the first of September, for travel between London and the continent on the London-Paris and London-Amsterdam routes. In that time they had 2 390 passengers, that is, 85 passengers a day. They have about 20 machines running regularly each day, ten each way, and they are mostly pretty well filled. There are some other lines

not doing so well, however. On some of the continental lines the percentage of business done to the available cargo space is very low. On one in particular the average cargo has been about half a passenger and 5 lb. express. Frequently the machine has been absolutely empty. I might cite my own experience in this connection. Flying from London to Paris in an eight-passenger machine every seat except one was filled. From Paris to London in a ten-passenger machine every seat was filled. From Paris to Brussels, in a 12-passenger machine, there was only one other passenger. From Prague to Paris in a six-passenger machine I was the only passenger, and the only other cargo was a little sack of mail weighing ten pounds.

Obviously there is a choice between routes, and the choice depends on the principles which must always govern the usefulness and popularity of an air route. Those principles are partly technical and, at present, partly political, but mostly economic. You must have a route over which the weather conditions are fairly uniform and where there is a considerable traffic made up of people in a great hurry or those who are the owners of goods which they are in a hurry to deliver. Such routes might be easy enough to find, but unfortunately there is another condition — the route must not be well served by the existing means of transportation. For example, the route between Boston and New York is already quite adequately served, and an air service would be impracticable as long as the New York airport is as at present, an hour from the city. The time by airplane would be about 2½ hours from field to field, but the total time would be 3½ hours at present. The perfection of the London-Paris route for aerial exploration results from the fact that the present means of transport are very slow and uncomfortable and a good many people are glad to avoid trans-shipment of themselves and their goods at the two sides of the Channel. It is rather amusing that a large amount of the express matter sent is perishable, being shipped by air, because the owners do not dare trust it to the express companies. Among the first shipments sent on this London-Paris route were several boxes of eggs.

When I say that the present means of transportation should be insufficient you have to look for the causes which may result

in their insufficiency. Those causes are found most commonly in natural obstacles, such as the English Channel or mountain ranges, and particularly canyons and depressions, which offer no obstacle at all to the airplane. In the case of Europe another severe travel barrier is found in the international boundaries, as all who have been there since the war can testify. Over there they have a jolly habit of turning you out at 3 o'clock in the morning to have your baggage examined. Every time you go across a boundary that proceeding is repeated, often on both sides of the boundary, but an airplane can pass right over a country without interference so long as it doesn't land. Also travelers by air receive very lenient treatment, the airports providing about one customs officer per passenger.

Another question which comes up in the choice of routes for air travel is whether travel is to be by night or by day. Here in this country competition with night trains must always be considered. For instance we should have to compete with the night train from Boston to Chicago, which covers the distance in 22 hours — 14 of them during the night. The airplane does it in 8, but must at present do it by day. It is probable that development of airplane lines will occur first in America in connection with the carrying of express, because the planes are not now prepared to carry people by air at night, but express can be flown at night with reasonable regularity. Night flying is now being regularly carried out by the Army. By introducing night operation, the air mail can be carried from coast to coast in 28 hours.

Another condition in picking a route is that we shall have good weather, and particularly absence of fog, to maintain the regularity of service. In that respect the London-Paris route is rather poor, interruption by weather conditions being frequent.

The success of the London-Paris line is particularly interesting to us because it gives an indication of the interest Americans are taking in air transport. If abroad, why not here? During the past summer the statistics of nationalities traveling between London and Paris show 50 per cent. American tourists. On that route, the Americans are furnishing fully half the business, and I hope we shall have a chance to

patronize lines in this country instead of going to Europe in the near future.

I said several moments ago I would leave for the time being, the matter of the gap between the cost of operating airplanes and the fares charged for riding in them. The gap is closed by the subsidies which exist in most European countries.

I want to dispel a few popular illusions regarding subsidies. There seems to be a general belief in this country that all air lines are subsidized and they could not operate otherwise. That is not true. There is at least one European line now operating without direct assistance between Lympne, on the English coast, and Ostend. There is another which has been running with a sort of negative subsidy — that is, the Government undertakes to make up one-third of the company's losses. If the company wins they don't get anything. This company operates running between London and Amsterdam. It has maintained regular daily service throughout the past year, and the total amount paid by the Government in subsidies was less than $9 000. Subsidies are, however, very liberal in some countries. In France they amounted to 23 000 000 francs two years ago, and 41 000 000 last year, and from latest information will probably come to 45 500 000 francs this year. Those figures are rather misleading, however, because the layout of the French lines takes into account imperial and colonial interests, and there is no real economic justification for some of them in the amount of traffic which they can attract.

To return again to America — there seems to be a common idea here that there is a strong propaganda for subsidizing in this country. Personally, I have never heard of any such agitation. Some of us have studied the matter, but no subsidy bill has ever been brought before Congress or has been put up for adoption. In the long run I think subsidies will prove harmful in some cases. A bad subsidy is worse than none. Consider the position France once took with respect to shipping subsidies. Under one subsidy law sailing vessels collected more than steamships. The result was that France was going from steam to sailing craft when all the rest of the world was making progress toward steam, and her operating firms were finding sailing more

profitable simply because they could collect a big subsidy. At the present time it is practicable to operate airplanes at a profit in some countries without carrying any cargo at all. This is a bad condition. Commercial aviation should be able to stand on its own feet soon.

Considering now the technical problems, I will present first a few pictures of the types of airplanes used in Europe on

FIG. 2. — A. D. H. 34 BIPLANE.

The type used by two of the companies operating on the London-Paris line. Equipped with a 450-h.p. engine, it carries eight passengers inside the cabin.

the air lines, including some in which I rode myself this summer. (Figs. 2 to 5.)

It has sometimes been the tendency of airplane designers to pay too much attention to efficiency, the amount of load per horse power, and too little to the point of view of the passengers — too little to the comfort of the machine. They have decorated the cabins elaborately, to be sure, but it is also very important to keep the cabins well ventilated and the seating arrangements comfortable, and most of all to obviate the noise, which is a serious objection. Great progress is now being made. Bad ventilation has practically disappeared, and the noise is very

FIG. 3. — PASSENGERS DISEMBARKING AT LONDON AFTER A CROSS-CHANNEL FLIGHT IN A HANDLEY PAGE.

The Handley Page biplane is twin-engined, carries radio and an operator, and is one of the largest types in regular service at the present time.

FIG. 4. — ANOTHER TWIN-ENGINED BIPLANE.

The Farman Goliath in which the writer flew from Paris to Brussels. Twelve passengers are accommodated in the two cabins.

much less marked than it was at first. It is now possible for passengers to converse with one another, without raising their voices to an uncomfortable degree. The planes are still pretty noisy, but much better than they were.

Before taking up the arrangement of airports I should like to say something about the operation of the airplanes themselves. The things we seek in operating are first, economy;

FIG. 5. — A FOKKER MONOPLANE.

In service between Brussels amd Amsterdam, as well as on the Königsberg-Moscow and other lines. The Fokker is among the lowest-powered commercial machines, having a single engine of 260 h.p.

second, safety — and we have gone a long way in that respect; and third, reliability. I want to go into safety statistics in detail for a moment.

The K. L. M. is a Dutch line running practically without subsidy and has flown in the past two years about 700 000 miles and never had a serious accident. The London-Paris lines this summer carried roughly 6 000 passengers and had but two accidents. One was a collision in the air and the other a very mysterious accident, the exact cause of which is still unknown. There was about one fatality out of every 2 000 persons carried.

Safety is largely a matter of operating experience and of careful attention to detail. Bad weather, of course, also comes into it; being overtaken by storms or fog; failures of the engine, causing forced landings and other unfavorable conditions, but the accidents are never due to failure of the airplane as such. The fault lies now in most cases rather with those operating than with those designing, and the number of fatalities is being largely reduced as more experience in operating is being gained.

As for reliability, that is again rather a question of maintenance than of design. You have heard from time to time of commercial airplanes, so-called. Views of some of them have been shown. The difference between these and the other planes lies chiefly in the size and the interior arrangement of the fuselage. There is nothing remarkable in the design of a commercial craft. What is most required is untiring attention to detail in maintenance, and if we get that we get reliability and safety. I want to emphasize that we can expect continual improvement in these particulars.

I want to cite specifically the record of one company during the past year. One company was operating a line between London and Paris. They owned three airplanes but had the misfortune early in the season to have two of those planes, while being driven across the field to tank up with fuel, run into each other and both had to go to the factory for repairs. This left them with but one machine. For one month they ran a service of two trips a day each way with the one airplane. They covered about 20 000 miles in that one month with that plane. After every 100 hours of flying they would change the engine overnight and start the next morning with a fresh engine. They kept the machine going all summer at nearly that same clip. Careful examination of the machine after it had had about 1 000 hours in the air, showed that it was then in nearly the same condition as when it left the factory. During about 1 500 hours of flight to date there had not been one forced landing due to engine trouble.

I shall pass over the question of navigation in order to get to that of landing fields. That is a question of particular interest at the present time because Boston is now laying out

an airport which is going to put us in the very forefront in this country as regards aerial facilities.

Once again I can best make my points through pictures with liberal captions, showing the equipment of some of the European airports.

Just a word about the application of this to the United States. You have seen in a general way what the present

FIG. 6. — THE SPAD IN WHICH THE WRITER TRAVELED FROM PRAGUE TO STRASBOURG.

The Spad is remarkable for its high speed, which is about 120 miles per hour, far above the average of commercial airplanes.

situation is in the United States. At the present time we have in America no air craft regulations except such as have been provided by a few of the states. In America there is no governmental encouragement of any sort for commercial flying. There have been no actual steps towards laying out airways for civil use, no attempt to do anything for commercial aviation. At the present time there is a bill before Congress — it is in the House now — to provide for a Bureau of Aeronautics to do some of these things.

This is the country of Wilbur and Orville Wright, and the airplane is largely a product of American genius. It seems

FIG. 7. — A FOUR-SEATER POTEZ BIPLANE.

One minute after a forced landing in a Czecho-Slovakian wheat field.

FIG. 8. — THE LANDING STAGE AT CROYDON, AND THE PASSENGERS LEAVING A GOLIATH.

Showing the lighthouse in the background. Light is thrown upwards directly, and also down on to the white base of characteristic form. This white target serves as an identifying mark for the field.

to me the time is ripe for America to adopt a firm and consistent air policy for the first time. We have had many courses of action, more or less wise, but we have never yet, as a nation, had an air policy. To summarize what I think such a policy should contain:

First. The passage of a bill for aircraft regulation and the establishment of a Bureau of Aeronautics;

Second. The laying out of a system of airways, useful alike in war and in peace;

FIG. 9. — THE OFFICES AND WAITING-ROOMS OF THE VARIOUS AIR TRANSPORT COMPANIES AT CROYDON, THE LONDON TERMINAL AIRPORT.

Third. Ratification of the National Air Navigation Convention, to put us in line with the rest of the world;

Fourth. The adoption of a measure whereby the Air Mail can be carried by private firms under contract with the Government. At present it is carried only by the Government directly. There is a bill now before Congress providing for the Post Office Department letting contracts to private companies to carry mail by air.

This I feel is the minimum action we must take before America can take her proper position in the field of commercial flying.

FIG. 10. — THE CROYDON TRAFFIC CHART.

Reports on the movements of machines in the air are received by radio and indicated on this board by moving little metal models of airplanes along a row of nails marking off the route. Models of different colors are used for machines of the different companies.

FIG. 11. — THE WEATHER BOARD AT LE BOURGET, THE PARIS AIRPORT.

The heights of the white strips on the board at the right indicate the heights of the lowest clouds at various points along the routes to be flown. Weather reports are received hourly by radio.

Vol. IX DECEMBER, 1922 No. 10

BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

BOSTON AIRPORT.

By R. C. Moffat.*

(Presented before The Affiliated Technical Societies of Boston, November 23, 1922.)

I will tell you briefly what we are going to have very shortly in Boston in the new airport, and something about how we came to get it.

Shortly after the war a lot of returned pilots in the Aero Club of Massachusetts, and Army officers at headquarters of the various divisions, interested in flying, started an agitation to try to get a landing field at Boston. This resulted in research work being done by one of the City engineers, who examined all possible locations, except the one finally adopted, which has since then been reclaimed from the harbor. It came down to about six locations which appeared possible, and the estimated cost of construction varied from $50 000 to $250 000 or more to put the fields in condition to be used as landing fields and so nothing very much was done until the fall of 1921. Then the Post Office Committee of the Chamber of Commerce trying to get the Air Mail Service extended to Boston, took up the matter of a landing field at Boston. They saw no chance of getting the Air Mail Service extended here without a field. They got authority from the Chamber of Commerce to take up the matter from all angles, and coöperated with the Army and Aero Clubs and found that a landing field was wanted here for several purposes — for the

* 1st Lt. Air Service, U. S. A.

Air Mail, individual owners, commercial and military flying. The Regular Army detachment at Framingham has a field, but that field is 20 miles from our office and is very inconveniently situated. Also a field is needed for the use of the National Guard now in the South Armory in Boston. They have no airplanes and will not have until there is a place to house them. So a bill was introduced in January, 1922, by which it was proposed that the State set aside land for the field and prepare it so planes could land on it, and that the Federal Government should put up the hangars.

The location of this field is on made land in East Boston, reclaimed from the harbor by hydraulic fill. The area is being extended all the time. The field will only cover a small proportion of this area, but will consist of two runways and a site for the hangars. The whole plot cost the State a couple of million dollars to construct. It was done for commercial purposes, and eventually will be used for factories, dock sites, etc. But at present Boston has there more ground than she can use. This land would otherwise lie idle, so the State has agreed to lease it to the Federal Government for ten years at a rental of $1 a year, provided the Government put up the hangars and allow the field to be used by the Air Mail and individuals or by anyone who will comply with the regulations of the officers in charge of the field.

The sketch of the field (Fig. 1) shows its general arrangement. The runway is 1 500 ft. long by 100 ft. wide and there is another one of the same length, forming a Tee. It will be surfaced with cinders for 100 ft. in width and smoothed and rolled for 50 ft. more on each side, making a total width of 200 ft. and a length of 1 500 ft. Building at the land end has been restricted so that no building can be more than 10 per cent. in height of its distance from the field, so the planes will have a clear approach to the runway and a clear takeoff from the field. As it is now there are no buildings for approximately half a mile in one direction and in the other three directions it is all water, so the field is ideal so far as the approach is concerned. The ground is level and the field is adjacent to deep water so that it is available for sea planes and land planes, both. The present plan is for two

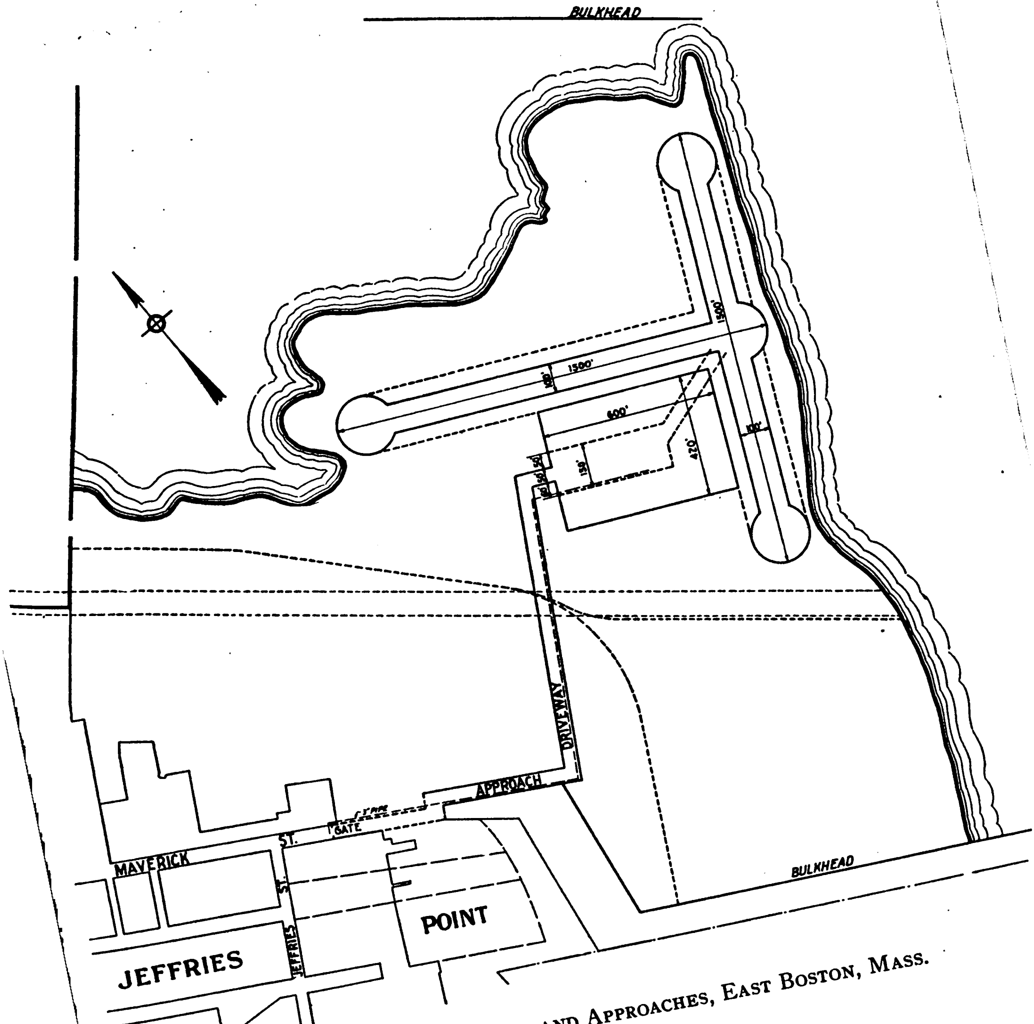

Fig. 1 — Aeroplane Landing and Approaches, East Boston, Mass.

Regular Army hangars for training reserve officers, etc., and two hangars for the National Guard; and also there is land along these runways which may be leased to individuals and commercial companies.

The road to the field is now all graded and it has cinders for a portion of its length. The two hangars are nearly completed. They will have a concrete floor and steel frame and will be metal covered buildings. They should be very good buildings for the purpose. The photograph taken from the air (Fig. 2) shows the location and the present stage of construction of the hangars. The field will be available to all planes and will be ample for some time to come. The Tee is placed so that no matter which way the wind is the plane can land approximately into the wind.

The contract for building the hangars has been let to various contractors and it is planned to lease the property next them for more hangars.

The story of how this field was finally put over is so complicated that I can't tell it entirely. I will just briefly touch on it. When the bill was introduced this land was in charge of the Committee on Public Lands and Harbors, so the bill was submitted to them. This committee first voted to hold it over to the next session. This action would have killed the bill. Finally it was decided that the committee should hold another hearing and it was decided that it should pass. As that committee had no money it was sent to the Committee on Ways and Means and it was decided to appropriate $35 000 to construct this field. If the expense should run over this amount it was decided that the balance must be raised from other sources. So the Chamber of Commerce agreed to see that the money was forthcoming should it be needed, and the bill finally passed in May, 1922. The contracts were let and signed on the very last possible day. The lease was signed June 28, sent by special delivery to Washington and signed on June 30 and was gotten over just in the nick of time. It was soon found, however, that $13 000 more would be needed and the Chamber started the fifth of July to raise $13 000 or $14 000 which they must have by August 15 or the hangars would not be built as the bids lapsed on that date. They got it and $1 700 to spare. There

FIG. 2 — HANGARS, EAST BOSTON LANDING FIELD.

are $3 800 also being held for some special purpose. I should like to call attention to the fact that over 500 individuals subscribed to this fund, and a good many people who subscribed were in no direct way interested in aviation. They were neither fliers nor interested in commercial aviation. They just thought it would be a good thing for Boston.

The runways are partly graded but the cinder surfacing has not been commenced. The field will not be ready to land on before next spring. Two of the hangars will be completed within a month and the other two within two months. They are on the way now to Boston and will probably take about four weeks to erect.

MEMOIR OF DECEASED MEMBER.

WILL B. HOWE.*

MR. WILL B. HOWE, City Engineer of Concord, N. H., since March 21, 1883, passed from an active and exceedingly efficient life April 1, 1922.

He was born in Concord, July 3, 1859, the son of William Holman and Mary (Carleton) Howe, both of old Revolutionary stock. He was a direct descendant of Joseph Howe who fought in the French and Indian War and was also a Minute Man at Lexington. The old Howe Tavern at Sudbury, Mass., immortalized by Longfellow as "The Wayside Inn" was built by an ancestor and occupied by three generations of Howes.

Mr. Howe graduated from Concord High School in 1876, beginning his life work in 1878 as rodman with Mr. Charles C. Lund, C. E. of Concord, principally on railroad work, including the construction of the Profile and Franconia Notch Railroad and location of the Bethlehem Branch.

After Mr. Lund's demise in 1880, Mr. Howe continued with his successors, Foss and Merrill, on location and maintenance on the B. C. & M. Railroad, the Concord Railroad and branches, and in general engineering work which included the Sewalls Falls power development in Concord.

In September, 1883, Mr. Howe went to Nova Scotia as principal Assistant Engineer on what is now known as the Central Railway with headquarters at Bridgewater, N. S., later becoming acting Chief Engineer until May, 1888, when he returned to Concord and assumed the management of the office of Foss and Merrill and so continued until March, 1893, when he was chosen Concord's first City Engineer, which position he retained until his demise.

Of his long and faitful service in Concord many monuments remain: his assessors' plans, methodically indexed; a wall

* Memoir prepared by Fred W. Lang and William H. G. Mann.

map of Concord City and environments: sewer and steel bridge structures put up under his careful and accurate supervision.

He was affiliated with many societies and lodges, among which may be mentioned the American Society for Municipal Improvements, the New Hampshire Good Roads Association, the National Geographic Society, member of the Boston Society of Civil Engineers since March, 1896, member Blazing Star Lodge, Trinity Chapter, Horace Chase Council, Mount Horeb Commandery, Bektash Temple A. A. O. N. M. S., New Hampshire Society of Veteran Free Masons, and was vice-president of the Council of the Order of High Priesthood. He was also a member of the New Hampshire Historical Society, the Men's Club of the South Congregational Church, the Wonolancet Club, the Concord Gun Club, and of the New Hampshire Society, Sons of the American Revolution, serving as secretary and treasurer the past two years.

In Nova Scotia, on January 22, 1889, Mr. Howe married Ida May Starratt, daughter of James Starratt, Jr., and Elizabeth Waterman, his wife. A daughter, Myrna, prominent as a war nurse in France is their only child.

Efficiency, economy, and a particularly good sense, were Mr. Howe's attributes as an engineer. As a man it is an honor to have been his friend and assistant.

Vol. IX JANUARY, 1922 No. 1

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPER IN THIS NUMBER.

"Highway Construction in Massachusetts." Arthur W. Dean.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, December 21, 1921.

The regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 8 o'clock by the first Vice-President, Frank M. Gunby.

There were 116 members and guests present.

The minutes of the meeting of November 16 were read and approved.

The Chairman announced that the Board of Government had elected the following to membership in the grades named:

Members — Messrs. A. O. Bradshaw, E. S. Clark, H. F. Heald and K. F. Jackson.

Juniors — Messrs. G. D. Ballou, P. E. Bodemer, F. W. Chase, Jr., L. H. Chouinard, H. H. Crossman, R. B. Ely, A. E. Everett, Jr., C. J. Ginder, E. R. Harlow, Jr., H. H. Jones, H. D. Johnson, Jr., F. E. Junior, H. W. Kelly, A. E. Kendrew, W. H. Law, C. G. Leavitt, Maurice Marcus, C. A. May, J. J. Meagher, E. M. Norberg, E. S. Parsons, W. M. Parsons, E. J. Pinkul,

C. T. Rhoades, Benjamin Rubin, J. C. Rundlett, J. B. Russell, A. L. Savignac, W. Semenyna, E. O. Stearns, C. S. Toole and G. D. Vincent.

The Secretary announced that, under authority of the Board of Government, the President had consummated the formation of the Section to be known as the "Northeastern College Section" of the Society.

The Secretary read a letter from the President welcoming the members of the Engineering Society of the Northeastern College as a section of the Boston Society of Civil Engineers.

The Chairman announced the death of William E. Baker, who died November 7, 1921, and was authorized to appoint a committee to prepare a memoir.

The Chairman then introduced the speaker of the evening, Mr. A. W. Dean, chief engineer, Division of Highways of the Public Works Department, Commonwealth of Massachusetts, who read a paper entitled "Highway Construction in Massachusetts." Mr. John R. Rablin, chief engineer, Park Division, Metropolitan District Commission, opened the discussion by presenting the practices of that department. The papers were then discussed by the following: Messrs. Macksey, Porter, Dorr, Rowe, Larned, Metcalf, Rice and Hodgdon.

Adjourned.

RICHARD K. HALE, *Acting Secretary.*

BOSTON, December 28, 1921. — A special meeting of the Boston Society of Civil Engineers was held this evening in the rooms of the Society in Tremont Temple, and was called to order at 8 o'clock by the Second Vice-President, Edwin H. Rogers.

There were 55 members and guests present.

The purpose of the meeting was for the discussion of tentative specifications for concrete and reinforced concrete prepared by a joint committee from the following societies: American Society of Civil Engineers, American Society for Testing Materials, American Railway Engineering Association, Portland Cement Association and American Concrete Institute. This report was submitted to the constituent organizations on June 4, 1921, and has been published in various journals and periodicals.

Mr. Leonard C. Wason opened the discussion and announced that the record of the meeting would be submitted to Professor Voss of Wentworth Institute, who has kindly consented to digest and edit the notes for the presentation to the joint committee.

The paper was then discussed by the following: Messrs. L. J. Towne, E. S. Larned, A. C. Tozzer, B. F. Guppy, H. F. Bryant, C. M. Spofford, W. C. Voss, C. E. Nichols, E. F. Allbright, Rice, Ramsey, Alvord, Woodruff and H. A. Varney.

Adjourned.

RICHARD K. HALE, *Acting Secretary.*

BOSTON, December 7, 1921. — A regular meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening in the Society rooms, Tremont Temple. The meeting was called to order at 7.50 P.M., by the Chairman, H. K. Barrows.

The records of the October meeting were read and approved.

The Chairman announced that the Executive Committee had elected to membership Messrs. J. Henry Duffy and Scott Keith.

The Chairman then introduced the speaker of the evening, Mr. Ralph W. Loud, assistant engineer, Sewerage Division, Metropolitan District Commission, who spoke on the Metropolitan Sewerage Works.

The subject was discussed by Messrs. Lamson, Stiff, Eddy and Marston.

Meeting adjourned at 10 P.M.

Members present, 41.

JOHN P. WENTWORTH, *Clerk.*

BOSTON, December 14, 1921. — The regular December meeting of the Designers Section of the Boston Society of Civil Engineers was called to order at 6.10 P.M. by the Chairman, Ralph E. Rice.

There were 42 members and guests present.

The minutes of the two preceding meetings were read and accepted.

Past President George F. Swain was introduced and gave an intensely interesting and instructive talk on earth pressure. The paper was then discussed by Messrs. F. A. Marston, C. B. Breed, L. F. Cutter and others, who brought out additional points of interest and value.

Meeting adjourned at 7.40 P.M.

A. L. SHAW, *Clerk*.

APPLICATIONS FOR MEMBERSHIP.

[January 15, 1922.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

FOWLER, WILLIAM H., Melrose, Mass. (Age 26, b. Needham, Mass.) Graduate of Lynn High School in 1914, and entered Mass. Inst. of Technology in September of that year, but, on account of ill health, left in February of 1916, to go on a country farm. In the fall of 1916 worked with Whitman & Howard, surveying and drafting; with Richardson & Hale from Nov., 1916, to Feb., 1917; with George W. Cutting, Jr., Feb. 5 to Apr. 24; and division engineer with the B. & M. R. R., Apr. 25 to June 28; enlisted in U. S. N. R. F. and served from Oct., 1917, to Jan., 1919; with the Boston Rubber Shoe Co. from Jan., 1919, until fall of that year; entered Northeastern College in the fall of 1919, and during the work periods was with Monks & Johnson as a draftsman, with the exception of five weeks with Turner Construction Co., on line and grade work; with the Highway Commission from June 1 to Oct. 22

on bridge construction. At present is attending Northeastern College. Refers to H. B. Alvord, G. W. Cutting, Jr., C. S. Ell, J. J. Harty, Jr.

INGALLS, JAMES W., Lynn, Mass. (Age 35, b. Lynn, Mass.) Graduate of Dartmouth College in 1910 with B.S. degree, also a graduate of Thayer School of Civil Engineering in 1911 with a C.E. degree, having completed the two-year course. From May to Sept., 1910, and May to June, 1911, assistant to the city engineer of Barre, Vt., on city work; also transitman on construction of a water-supply reservoir; June to Nov., 1911, junior topographer with the U. S. Geological Survey at Montpelier, Ida.; Nov., 1911, to May, 1912, draftsman with J. P. Snow on railroad and highway, timber and steel bridges; May to Dec., 1912, instrumentman on the N. E. R. R. at Brimfield, Mass., on construction work; Jan. to Apr., 1913, track supervisor at Central Aquirre, P. R.; June, 1913, to June, 1919, with the engineering department of the Maine Central R. R., as transitman, then assistant engineer, then resident engineer; June, 1919, to Aug., 1921, treasurer and general manager of the J. F. Ingalls, Inc., Lynn, Mass. At present president of J. F. Ingalls, Inc., not actively in business; since Sept., 1921, instructor in civil engineering at Northeastern College, Refers to H. B. Alvord, C. S. Ell, R. E. Parker, J. P. Snow, B. T. Wheeler and H. C. Whittemore.

LIST OF MEMBERS.

ADDITIONS.

BRASK, HENRY	23 12th St., Attleboro, Mass.
COOK, HAROLD S.	88 Auckland St., Dorchester, Mass.
COOPER, CHARLES S.	4 Perth St., Dorchester, Mass.
CUNDARI, JOSEPH V.	756 Third St., South Boston, Mass.
HARDING, ARTHUR E.	111 Gainsboro St., Boston, Mass.
HEALD, HAROLD F.	171 Powder House Blvd., Somerville, Mass.
HOAR, WILLIAM V. P.	1061 Dorchester Ave., Dorchester, Mass.
MILNE, DAVID C.	188 Washington St., Dorchester, Mass.
PINKUL, EDWARD J.	4 Leslie St., Dorchester 22, Mass.
THOMPSON, HAROLD C.	32 Auburn St., Bridgewater, Mass.
WILLEY, LAWRENCE V.	50 Gloucester St., Boston, Mass.
WILLIAMS, EDWIN C.	15 Harvard St., Natick, Mass.

CHANGES OF ADDRESS.

BIGELOW, LYMAN W., Care United Fruit Co., Engrg. Div., Puerto Barrios, Guatamala, C. A. Via New Orleans.

BURRAGE, HENRY T., Care Capt. A. W. Burton, Fort Moultnè, Charleston, S. C.

CONNOR, BERNARD D.	7 Monroe St., Somerville, Mass.
HORNE, HAROLD W.	603 Belmont St., Belmont, Mass.
SAVAGE, J. DANA.	334 Malden St., Medford, Mass.
SNOW, BENJAMIN H.	28 Lebanon St., Winchester, Mass.
STEARNS, RALPH H.	Room 306, Hall of Records, New York, N. Y.
TURNER, HOWARD M.	120 Tremont St., Boston, Mass.

LIBRARY NOTES.

Recent Additions to the Library.

U. S. Government Reports.

Activities of the Bureau of Yards and Docks. 1917–18.

Librarian of Congress, Report of. 1921.

Superpower Survey Report. W. S. Murray and others. 1921.

Wood-using Industries of New York. U. S. Department of Agriculture.

United States Coast and Geodetic Survey. 1921.

State Reports.

Massachusetts. Annual Report Highway Commission. 1910–1911.

Massachusetts. Annual Report Metropolitan District Commission. 1920.

Rhode Island. Annual Report Public Utilities Commission. 1920.

City and Town Reports.

Melrose, Mass. Annual Report Public Works Department. 1920.

New Orleans, La. Semi-Annual Report Sewerage and Water Board. 1920.

New York, N. Y. Contracts 209, 210, 211, Board of Water Supply. 1921.

Philadelphia, Pa. Annual Report Bureau of Surveys. 1919–1920.

Miscellaneous.

Practical Least Squares. Ora Miner Leland. Gift of publisher.

Proceedings of A. S. T. M. 1921. Gift of L. C. Wason.

Library Committee.

Vol. IX FEBRUARY, 1922 No. 2

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPER IN THIS NUMBER.

"Characteristics of Some Connecticut Sludges." By J. Frederick Jackson and J. Doman.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, January 25, 1922. A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 7.50 P.M. by the President, Robert Spurr Weston.

There were 55 members and guests present.

The minutes of the meetings of December 21st and 28th were read and approved.

The Chairman announced that the Board of Government had elected to membership the following candidates in the grades named:

Honorary — Mr. William Edward McClintock.

Members — Messrs. Erol G. Dary, Frank L. Flood and Winthrop E. Nightingale.

Juniors — Messrs. George L. Burke, Walter H. Lee, Edward B. Murdough, Chester L. Nyman, Roger G. Oakman, Alfred D. Parsons, Samuel A. Riggio and Herman C. Stotz.

The President announced the death of Charles A. Pearson on December 11, and was authorized to appoint a committee to prepare a memoir.

The Secretary presented a memoir of Richard Hutchinson which had been prepared by Mr. I. E. Moultrop. The memoir was accepted and ordered printed in the Journal.

The President announced that the Legislative Committee had studied the subject matter of Bill 7541, which is before the House of Representatives in Congress, providing for the commissioning of engineers in the Public Health Service, and it had recommended the passage of the following resolution:

"*Resolved*, that the Boston Society of Civil Engineers endorse the Congressional Bill, H. R. 7541, giving a commissioned status to Sanitary Engineers in the Public Health Service of the United States."

The Board of Government at its meeting on December 21st,

"*Voted*, that the resolution be reported to the Society with the recommendation that it be adopted."

The President stated that notice of this had been sent out with the notice of the regular meeting as prescribed by the By-Laws, and that if adopted by the meeting would be sent out to the membership on letter ballot. He further stated that unless it was otherwise directed, the action of the Society could be reported to the Federated American Engineering Societies for the necessary action. Thereupon the resolve was unanimously adopted.

The President then described the work that had been done towards the formation of an affiliation of technical societies in Boston, and stated that the question would be presented before the Society at its next meeting.

Past President Howe addressed the Society and requested that additional funds be subscribed towards the Tinkham Memorial.

Mr. Thomas C. Atwood of the T. C. Atwood Organization of Raleigh, N. C., then presented a paper entitled "Special Methods of Handling Cost Plus Work for a Southern University." The paper was illustrated with lantern slides.

Adjourned.

RICHARD K. HALE, *Acting Secretary.*

Boston, January 11, 1922. A regular meeting of the Designers Section was called to order this evening in the Society Rooms, at 6.10 o'clock, by the chairman, Ralph E. Rice.

The subject of the evening was "Heating and Ventilating." Mr. A. C. Bartlett, Ventilating Engineer and Secretary of the Boston Chapter, American Society of Heating and Ventilating Engineers, was introduced and addressed the section on "What is Ventilation?" outlining the progress of the art from its earliest development down to the most modern conception.

He was followed by Mr. F. O. Alden, Sales Engineer for the Pierce, Butler and Pierce Manufacturing Corporation, who gave many practical suggestions for the design and installation of the various modern systems of heating and ventilation, and urged coöperation between architect and heating and ventilating engineers in the very early stages of building design, in order to avoid later difficulties in accommodating suitable devices to the space provided.

Thirty were present at this most instructive meeting, which was adjourned at 7.40 P.M.

Arthur L. Shaw, *Clerk.*

APPLICATIONS FOR MEMBERSHIP.

[February 15, 1922.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

BLANK, WESLEY HOWARD, Winchester, Mass. (Age 27, b. Winchester, Mass.) Graduated from Mass. Inst. of Technology in civil engineering, in 1916, with degree S.B. From June, 1916, to September, 1918, was draftsman with McClintic, Marshall Co., Pottstown, Pa.; September, 1918, to December, 1919, was a lieutenant in charge of an Anti-Aircraft Battery in France; January, 1920, to September, 1921, designer, estimator and structural engineer with Shoemaker Satterthwait Bridge Co., Pottstown, Pa. During the latter part of this last period was engaged on bids for sales department and had complete charge of preparing designs. He resigned the above position to take up advanced work at college and later to go into business, and accepted a position as instructor in Bridge Design at Mass. Inst. of Tech., where he is at present engaged. Refers to H. K. Barrows, G. A. Sampson, C. M. Spofford and C. H. Sutherland.

DICKSON, ARTHUR DONOHUE, Newtonville, Mass. (Age 29, b. Cambridge, Mass.) Graduate of Mass. Inst. of Tech. in 1917, with degree of S.B. in civil engineering. For a year and a half before entering preparatory school was office assistant and assistant foreman with George W. Macauley; assistant superintendent of construction with Stone & Webster at Falls Village, Conn., during the summer of 1916; during the war was second lieutenant in the Coast Artillery Corps, Regular Army, and later was promoted to rank of captain; in January, 1919, became assistant structural sales agent with the Bethlehem Steel Co., and assistant sales engineer, Bethlehem Stee Bridge Corp., New England district, and recently promoted to structural agent and sales engineer for the distrct. Refers to H. P. Eddy, Jr., J. W. Howard, C. M. Spofford, E. D. Storrs and J. W. Storrs.

GANNON, GEORGE H. P., Cleveland, O. (Age 26, b. Clinton, Mass.) Graduate of Worcester Polytechnic Institute in 1917. From May to Sept., 1917, was a designer at Colts Patent Fire-arms, Hartford, Conn., from Sept., 1917 to Sept., 1918 chief tool designer with a firm in Dayton, Ohio; during the war he was a secret service agent in munition plants; instructor in machinery design and kinematics in Cleveland, O., in 1918; assistant mechanical engineer from May, 1919 to the present with the National Lamp Works, Cleveland, O. Refers to the Cleveland Engineering Society.

HANLEY, JOHN MERRILL, Milton, Mass. (Age 24, b. Dorchester, Mass.) Graduated from Mass. Institute of Technology in 1918, with degree from M. I. T. and Harvard Engineering School of B. S. Summer of 1917 was a rodman with the Metropolitan Water Works, also spent two weeks at Technology Engineering Camp as assistant instructor in surveying; during the spring

of 1918 was assistant instructor in surveying at Mass. Institute of Technology, Cambridge, and in the fall of 1918 was in the Coast Artillery School at Fortress Monroe and received commission of second lieutenant; from March 1919 to Aug., 1919 draftsman and surveyor with the inspection department of the Associated Factory Mutual Fire Insurance Co's.; from Aug., 1919 to Sept., 1920 assistant engineer on automatic sprinklers, layouts and approval of plan and installations; from Sept., 1920 to the present, editor of special inspection reports on Fire Protection with rating of assistant engineer. Refers to J. B. Babcock, H. L. Carter, J. W. Howard, C. M. Spofford.

HOBBS, SAMUEL, Reading, Mass. (Age 30, b. Pelham, N. H.) Graduated from the Nashua, N.H. High School in 1907 and from Dartmouth College, with the degree of B.S. in 1912, and from the Thayer School of Engineering connected with Dartmouth College, in 1913, with the degree of C.E. From May to September, 1912, served as inspector at the Asphalt Mixing Plant, Nahant, on the construction of the Lynn-Nahant boulevard. After graduation entered the employ of the Mass. Highway Commission and continued there as a resident engineer on contract construction work until September 1, 1919, under F. C. Pillsbury, Division Engineer; since that time has been engaged in estimating and supervising work for Rowe Contracting Co., also had charge of construction of the Hingham-Norwell concrete road on the Plymouth highway and various other street construction contracts with the State Highway Division, Metropolitan District Commission, City of Boston, etc. At present is with the Rowe Contracting Co. Refers to R. W. Coburn, A. W. Dean, A. P. Rice, R. J. Rowe, J. A. Tomasello, R. E. Whitney.

WILKINS, HENRY MUNROE, Marblehead, Mass. (Age 22, b. Marblehead, Mass.) Graduated from the High School in Marblehead in 1917 and entered Northeastern College in September of that year. During the five-week work periods has been employed as rodman and transitman with Whitman & Howard, as transitman with Aspinwall & Lincoln; in the engineers office of the Land Court, Commonwealth of Massachusetts, as computer; graduated from Northeastern College in June, 1921, since which time he has been with the Mass. Highway Commission as civil engineer Grade B, doing general office work and as inspector on a bituminous macadam road. Refers to C. S. Ell, C. Howard, L. B. Hoyt, C. B. Humphrey, E. H. Lincoln.

LIST OF MEMBERS.

Additions.

AIMO, KARL H. . . . . 56 Riverdale St., Allston 34, Mass.
ALLEN, EARLE C. . . . . 1 Linfield St., Holbrook, Mass.
BALLOU, GEORGE D. . . . . 86 Barry St., Dorchester, Mass.
CLARK, ELDON S. . . . . 23 Beaumont St., Boston 24, Mass.
CUMMINGS, JOHN J. . . . . 25 Edgewood St., Roxbury 19, Mass.
DEARBORN, ELMORE L. 50 Gloucester St., Boston, Mass.
DIXON, HERBERT C. . . . . 5 Blake Court, Gloucester, Mass.
ELY, RODNEY B. . . . . 8 Brown St., Salem, Mass.
FITZPATRICK, JOSEPH B. . . . . 9 Greene St., Somerville, Mass.
GARGARO, ALFRED . . . . 294 Willard St., Quincy 69, Mass.
JOHNSON, HENRY D. . . . . Y.M.C.A. 618, Boston 17, Mass.
KELLY, HAROLD W. 114 Radcliffe St., Dorchester, Mass.
KENNEY, DAVID J. 24 Cunningham St., Dorchester, Mass.
LEAVITT, CURTIS G. . . . . 44 Ashland St., Taunton, Mass.
MEAGHER, JOHN J. . . . . 1254 Gorham St., Lowell, Mass.
McMANUS, JOHN P. . . . . 19 Whiting St., Boston 19, Mass.
NORBERG, ERNEST M. . . . . 171 Park St., Medford, Mass.
RHOADES, CLIFFORD T. . . . . Pleasant St., Bridgewater, Mass.
ROSENBLATT, IRVING . . . . 10 Lovering St., Saxonville, Mass.
WILCOX, ARTHUR L. . . . . 3 Bancroft St., Maynard, Mass.
WILLIAMS, W. QUINTIN . . . . 1003 Rue de Quai, Port-au-Prince, Haiti.

Changes of Address.

COLE, HAROLD S. . . . . 74½ East Main St., Amsterdam, N. Y.
DURGIN, CLYDE M. . . . . Care Narragansett Electric Light Co.
360 Eddy St., Providence, R.I.
EISNOR, JOHN J. . . . . 19 Day St., West Somerville, Mass.
GARVEY, JOHN C. . . . . 520 Lake Drive, Milwaukee, Wis.
KLINK, NASSIME S. 314 Faneuil St., Brighton 35, Mass.
MACLEAY, FRANCIS R. 511 State House, Boston, Mass.
McCORKINDALE, RALPH I. . . . . 69 Sycamore St., Holyoke, Mass.
RABLIN, JOHN R. . . . . 1 Ashburton Pl., Boston 9, Mass.
WORCESTER, ROBERT J. H. . . . . Care Lockwood, Greene & Co.
Box 613, New Braunfels, Tex.

Death.

PEARSON, CHARLES A. . . . . December 11, 1921.

LIBRARY NOTES.

Book Review.

"Practical Least Squares," by Professor Ora M. Leland, New York, 1921. McGraw-Hill Book Company, Inc. 251 pages, 48 cuts.

Reviewed by George L. Hosmer.*

This book is planned so that the essentials of a course in the adjustment of observations can be taught to engineering students in about 16 lessons. The introduction of so many new subjects into the curriculum of engineering schools has either crowded out the subject of least squares entirely or reduced the available time to a few hours. It is only by careful planning and with a suitable text-book that good use can be made of so short a time. The arrangement of this book seems to be admirably adapted to meet these conditions.

The first six chapters deal with the adjustment of observations of the sort likely to be made by the engineer. This is the most important part of the subject from the practical standpoint. If the time devoted to the course were so limited that only this portion of the book could be studied, the student would have a good idea of what is to him the most important branch of least squares. If time permits, however, the course may be made to include a brief discussion of the determination of the constants in empirical formulas, to which one chapter (VII) is devoted, and the computation of the precision measures of the adjusted quantities and the rejection of doubtful observations, which are covered in chapters VIII and IX. All matter not immediately necessary for the determination of the most probable values of measured quantities is put at the end of the book.

The statements and explanations are written in a clear style which the student can easily follow. The descriptions of the process of eliminating the unknowns in the normal equations and of the (Doolittle) abridged method of solution are particularly clear. Throughout the book there are good practical suggestions for the arrangement of the calculations and methods of carrying

* Associate Professor of Topographical Engineering, Mass. Inst. of Tech., Cambridge, Mass.

out the solution; these should be helpful to the student. A single careful reading of the book reveals very few typographical errors. The experienced computer might be tempted to criticize the length and amount of detail of some of the explanations, but the student who is puzzling for the first time over the formation and solution of normal equations or the selection of condition equations will need all these helps even if he does not appreciate their value. This book should appeal to all those instructors who face the task of teaching the subject of least squares in a very limited number of exercises. For the student intending to go more deeply into the matter this book ought to serve as an easy introduction to the more elaborate treatises.

Recent Additions to the Library.

U. S. Government Reports.

Chief of Engineers, U. S. Army, Report of. Parts 1 and 2. 1921.

State Reports.

Massachusetts. Report of Department of Public Utilities. Vol. 2 1920.

Municipal Reports.

Erie, Pa. Annual Report Commissioners of Water Works. 1920.

Manchester, N. H. Report on Sewerage. L. H. Shattuck, Inc. 1921.

Miscellaneous.

Mineral Production of Canada. 1920.

Production of Coal and Coke in Canada. 1920.

Sewage and Sewage Disposal. Metcalf & Eddy. Gift of Publisher.

Westinghouse, George, Life of Henry G. Prout. Gift of Clemens Herschel.

Library Committee.

Vol. IX MARCH, 1922 No. 3

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPER IN THIS NUMBER.

"Special Features and Handling of 'Cost-Plus' Contract at a Southern University." By Thomas C. Atwood.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, February 15, 1922. A regular meeting of the Boston Society of Civil Engineers was held this evening at Lorimer Hall, Tremont Temple, and was called to order at 7.30 P.M. by the President Robert Spurr Weston.

The minutes of the January meeting were read and approved.

The President announced that the Board of Government had elected Mr. James W. Ingalls to membership in the Society.

The Secretary read a letter from Mr. William E. McClintock accepting the honorary membership to which he had been elected.

The President then called upon Past President Leonard Metcalf, Chairman of the Committee on Inter-Society Relationship, who presented a report of the Board of Government concerning the formation of the Affiliated Technical Societies of Boston and recommended the adoption of the following resolution:

"*Be it Resolved that:* The Boston Society of Civil Engineers approved the purpose and general provisions of the constitution of the Affiliation of Technical Societies of Boston submitted with the notice of the meeting of January 25, 1922; that it join the Affiliation; and that its Board of Government be and is hereby directed and empowered, by itself or through such representatives as it may appoint, to take any and all steps that may be necessary to assist in perfecting the organization of the proposed Affiliation and to effect the participation of this Society as a member thereof, and, further, to negotiate and make in behalf of this Society the necessary working agreement to govern the relations, rights and obligations of the Affiliation and the Boston Society of Civil Engineers."

The resolve was adopted by a unanimous vote of the meeting. It was thereupon voted that the Secretary submit this resolve by letter ballot to the members of the Boston Society of Civil Engineers for their action.

The meeting thereupon adjourned and a joint meeting of the Boston Society of Civil Engineers, Boston Section American Society of Mechanical Engineers, and the Boston Section American Institute of Electrical Engineers was called to order, with the President, R. S. Weston in the chair.

The Chairman then introduced Mr. Gerrit Fort, Vice-President of the Boston & Maine Railroad, who read a paper on "Problems of Freight Transportation in New England;" and Mr. Benjamin Franklin Fitch of the Motor Terminals Company of New York, who read a paper on the "Co-ordination by the Unit Containers System by the Railways, Waterways, Highways and Traction Lines for a Relief of New England Transportation." There were 100 members and guests present.

The meeting adjourned at 10.30 P.M.

RICHARD K. HALE, *Acting Secretary.*

BOSTON, February 28, 1922. A special meeting of the Boston Society of Civil Engineers was held jointly with the Boston Section, American Society of Mechanical Engineers and the Boston Section, American Institute of Electrical Engineers this evening in Lorimer Hall, Tremont Temple.

The meeting was called to order at 7.45 by Dugald C. Jackson, Chairman, Boston Section, American Society of Mechanical Engineers.

Honorable John N. Cole, Commissioner of Public Works, Commonwealth of Massachusetts, read a paper on " Problems Due to the Growth of the Motor Truck as a Freight Carrier;" and Professor W. K. Hatt, Director of Advisory Board on Highway Research, read a paper on " General Situation in Highway Transport and the Need of Research in that Field."

There were present 150 members and guests.

RICHARD K. HALE, *Acting Secretary.*

BOSTON, March 1, 1922. The Sanitary Section of the Boston Society of Civil Engineers held its annual meeting this evening.

At 6.15 P.M., an informal dinner was held at the Boston City Club.

At 7.50 P.M., the business meeting was called to order in the Society Rooms, by the Chairman, H. K. Barrows.

The records of the January meeting were read and approved.

The annual report of the Executive Committee was read and accepted.

Edgar S. Dorr for the Nominating Committee presented the following nominations for officers for the ensuing year:

Chairman — Arthur D. Weston.
Vice-Chairman — John P. Wentworth.
Clerk — H. P. Eddy, Jr.
Executive Committee —
Dana M. Wood.
George A. Sampson.
Ralph W. Loud.

On motion of Robert Spurr Weston, the Clerk was instructed to cast one ballot for the officers as nominated.

The final report of the Committee on " Methods of Design and Construction, and Results of Operation of Submerged Pipe Lines for Outfall Sewers " was presented by George A. Sampson.

On motion of Mr. Metcalf it was voted to accept the report and to print it in the JOURNAL.

The Chairman then introduced Dr. David L. Belding, Biologist, Division of Fisheries and Game, Department of Conservation of Massachusetts, who presented a paper on "The Effect of Pollution on Fish Life."

The paper was discussed by Messrs. Hale, Metcalf, Arthur D. Weston and Robert Spurr Weston.

On motion of Mr. Metcalf, a rising vote of thanks was given to Dr. Belding for his courtesy in presenting the paper of the evening.

Chairman Barrows then presented the incoming Chairman, Mr. Arthur D. Weston.

Adjourned at 10.00 P.M.

Members and guests present at the dinner, 13.

Members and guests present at the business meeting, 30.

JOHN P. WENTWORTH, *Clerk.*

BOSTON, February 8, 1922. A regular meeting of the Designer's Section was called to order at 6.15 P.M. Twenty were present. The minutes of the two previous meetings were read and accepted. Chairman Rice announced the appointment of a Nominating Committee as follows; — Ralph W. Horne, Henry C. Sheils and James S. Crandall, to report at the Annual Meeting in March.

Mr. O. A. Olstad, New England Manager for the Blaw-Knox Company, was then introduced and described the development and application of steel forms for concrete structures of various types, illustrating his talk with slides and by means of the reflectorscope.

Meeting adjourned at 8.00 P.M.

ARTHUR L. SHAW, *Clerk.*

BOSTON, January 20, 1922. — The first regular meeting of the Northeastern College Section of the Boston Society of Civil Engineers was held this evening at the Society rooms, Tremont Temple.

Organization of the Section was the purpose of the meeting, which was called to order by Mr. E. C. Allen, acting as chairman. There were 24 members present.

The following members were elected as officers:

Chairman — Mr. E. C. Williams.
Vice-Chairman — Mr. E. S. Parsons.
Clerk — Mr. K. H. Aimo.
Executive Committee —
Messrs. F. L. Flood.
A. S. Dawe and
D. C. Milne.

President Robert S. Weston, being introduced by the Chairman, then gave an interesting and instructive lecture on "Water".

A motion was made and seconded that the Chairman be given the power to make all arrangements necessary for the group picture of the Section, for the 1922 "Cauldron". Motion was passed.

Meeting adjourned.

KARL H. AIMO, *Clerk*

APPLICATIONS FOR MEMBERSHIP.

[March 15, 1922.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

CHIESA, ORIDIO DELLO, Quincy, Mass. (Age 22, b. Quincy, Mass.) Graduate of the Quincy High School in 1917, after which he took a course at the Franklin Union in structural detailing and design and reinforced concrete. Employed by the A. L. Smith Iron Works of Chelsea, first as blue print boy, then as draftsman and later was promoted to the estimating department and is still serving in that capacity. From October 1918 to December 1918 served in the S. A. T. C. Refers to E. P. Adams, J. J. Horgan, A. F. Probst and A. O. Wilson.

CONNOLLY, WILLIAM A., Allston, Mass. (Age 27, b. Roxbury, Mass.) Graduated from Mechanic Arts High School 1910, and received a diploma as a Military Engineer at Wentworth Institute in 1917. From 1917–19 he supervised construction in France; at present he is a general contractor and builder, in business for himself. Refers to F. H. Dillaby, W. H. Ellis, W. F. Pike, H. C. Sheils, and J. F. Travers, Jr.

CROISER, CHARLES L., Pittsburg, Pa. (Age 26, b. Hadley, Mass.) Graduated from Mass. Inst. of Tech. in 1916 in Sanitary Engineering. Was assistant in civil engineering at Technology 1916–1917; 1917 to date with Morris Knowles, Inc., Pittsburg, Pa., on engineering investigations, reports, design and supervision of construction. Refers to H. K. Barrows, M. Knowles, D. Porter, A. D. Weston and G. C. Whipple.

DAVIS, HAROLD FRANCIS, Reading, Mass. (Age 30, b. Reading, Mass.) Was a rodman with James A. Bancroft, Reading, on sewers and surveys from Sept. 1910 to Jan. 1911; transitman with C. R. Herrick, January 1911 to November, same year; November 1911 to September 1912, transitman with James A. Bancroft on surveys; September 1912 to April 1917 transitman and principal assistant with C. E. Carter on sewers, surveys, topography and subdivisions; April 1917 to July 1919 in the U. S. Army as sergeant and second lieutenant; August 1919 to May 1920 timekeeper with Mass. Highway Commission; May 1920 to November 1921, principal assistant with Dana F. Perkins on general surveys and topography; November 1921 to date a member of the firm of Davis & Abbott, C. E., Reading, Mass. Refers to H. K. Abbott, C. E. Carter, R. E. DeMerritt and C. W. Rolfe.

DOVE, ALBERT C., Wilmington, Mass. (Age 30, b. Roxbury, Mass.) Graduated from Mechanic Arts High School, Boston, 1910, specializing in engineering subjects. April 1911 to October 1914 with Aspinwall & Lincoln, Boston, as draftsman, transitman and chief of party; October 1914 to July 1917 draftsman and engineering assistant in the Metropolitan Park Commission; since July 1917 in the U. S. Navy Dept., on inspection duty at Fore

River Plant; during 1918 and 1919, resident naval inspector at George Lawley & Son Corp., Neponset; and later transferred to Squantum Plant as chief draftsman. Is preparing to become an instructor in engineering subjects. At present is inspector and draftsman in the office of the superintendent constructor for U. S. Navy, Quincy. Refers to D. A. Ambrose, W. H. Cronin, E. H. Lincoln and J. R. Rablin.

EDDY, HARRISON P., Jr., Newton Center, Mass. (Age 27, b. Worcester, Mass.) Graduated from Mass. Institute of Technology in 1917 as a sanitary engineer. Studied naval architecture and ship construction at Boston Navy Yard, April to December 1917; commissioned ensign in construction corps, U. S. N. R. F. December 1917 to February 1919; from 1919 to date assistant engineer on general civil engineering work at Metcalf & Eddy's. Refers to F. S. Bailey, C. E. Carter, R. K. Hale, F. A. Marston and A. L. Shaw.

GIBSON, JAMES RICHARD, Medford, Mass. (Age 47, b. Medford, Mass.) Educated in the public schools of Medford. He has been in the building business for twenty-eight years. Is now a building contractor. Refers to C. R. Gow, C. A. Leary, C. A. Miller, H. C. Sheils, J. F. Travers, Jr., and A. K. Williams.

RANDLETT, FREDERICK J., Boston, Mass. (Age 22, b. Boston, Mass.) Educated in the Boston Public High School, Wentworth Institute in Architectural Construction, and an evening course at Wentworth Institute in 1921, and is now taking an evening course in estimating at the Franklin Union. In the summer of 1919 was employed by the Aberthaw Construction Co., as a plan clerk; the summer of 1920 assistant engineer for the town of Milton, also as inspector on sewer and road construction; since the fall of 1920 with F. H. Randlett as a carpenter foreman. Refers to P. Gianni, H. A. Gray, F. E. Leland, A. G. Martin, E. P. Rankin and E. A. Varney.

LIST OF MEMBERS.

ADDITIONS.

BODIMER, PHILIP E.	94 Wendell St., Cambridge, Mass.
BRADSHAW, ALFRED O.	17 Prospect St., Amesbury, Mass.
BURKE, GEORGE L.	51 Concord Ave., Norwood, Mass.
CHASE, FRED W., Jr.	251 High St., Newburyport, Mass.
CROSSMAN, HARTWELL H.	102 Gainsboro St., Boston 17, Mass.
DARY, EROL G.	144 Central Ave., Hyde Park, Mass.
DAWE, ALLEN S.	8 Appleton St., Cambridge, Mass.
EVERETT, ALBERT E., Jr.	114 Waverly St., Everett, Mass.
FURRIER, JOSEPH P.	19 Tudor St., Lynn, Mass.
GINDER, CHESTER J.	23 Russell St., Everett, Mass.
HARLOW, ELMER R.	3 Mayflower St., Plymouth, Mass.
INGALLS, JAMES W.	63 Graves Ave., East Lynn, Mass.

Jackson, Karl F. .... 6 Beacon St., Boston, Mass.
Jones, Harold H. ....25 Franklin Ave., Swampscott, Mass.
Junior, Francis E. .... 416 Newbury St., Boston, Mass.
Kendrew, Albert E. .... 12 Highland St., Roxbury, Mass.
Law, William H. .... School St., Rockport, Mass.
Lee, Walter H. .... 231 Callender St., Dorchester 25, Mass.
May, Charles A. .... 424 Mass. Ave., Boston, Mass.
Marcus, Maurice .... 331 Seaver St., Dorchester, Mass.
Murdough, Edwin B. .... 25 Windemere St., Dorchester, Mass.
Nightingale, Winthrop E. .... 73 Hovey St., Watertown, Mass.
Parsons, Alfred D. .... 204 Foster St., Melrose, Mass.
Parsons, Edward S. .... 705 Washington St., Gloucester, Mass.
Parsons, William N. ....705 Washington St., Gloucester, Mass.
Rubin, Benjamin .... 85 Ruthven St., Roxbury, Mass.
Savignac, Alphonse ....80 Friend St., Amesbury, Mass.
Toole, Cameron S. ....50 Gloucester St., Boston, Mass.
Vincent, George D. .... 11 Langdon Ave., Watertown, Mass

Changes of Address.

Barry, C. Gardner .... 11 Joy St., Boston, Mass.
Beard, Capt. Cornelius .... Care Curtis Pub. Co., 366 Madison Ave. New York, N. Y.
Bigelow, Lyman W. .... 32 Larch St., Providence, R. I.
Brock, Nathan S. .... Gilboa, N. Y.
Budd, George, Jr. .... 8 West View St., Lowell, Mass.
Curtis, Greely S. .... 1109 Boylston St., Boston, Mass.
Douglas, Walter B. .... Care New Eng. Structural Co., Everett, Mass
Durham, Major H. W. ....Care Foundation Co., Calle Rifa 332, Lima, Peru.
Fair, Gordon M. .... Care Cuyahoga County Public Health Assoc. 514 Electric Bldg., Cleveland, Ohio.
Hannah, Thomas E. .... 14 Waverly St., Fitchburg, Mass.
Hering, Rudolph ..... Apt. 22, 550 West 157th St., New York City, N. Y.
Jackson, Ralph T. .... 3 Rollins Place, Boston, Mass.
Jonsberg, F. F. .... Room 819, 6 Beacon St., Boston, Mass.
Reed, Carl B. .... 1401 East 88th St., Cleveland, Ohio.
Sherry, Frank E. .... 14 Beacon St., Boston 9, Mass.
Tucker, Lester W. .... 17 Addison Ave., Rutherford, N. J.
Wood, Henry B. .... 245 Commonwealth Pier, S. Boston, Mass.

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Water Supply Paper. No. 500-C.

State Reports.

New Hampshire. Report of Public Service Commission. 1920.

New Jersey. Annual Report State Department of Health. 1921.

New Jersey. Report on Water Resources of the State and their Development. Hazen, Whipple & Fuller.

New York. Report State Bridge and Tunnel Commission. 1921.

Municipal Reports.

Louisville, Ky. Annual Report of Commissioners of Sewerage. 1921.

Providence, R. I. Annual Report Water Supply Board. 1921.

Miscellaneous.

American Civil Engineers' Handbook. Merriman.

Architects' and Builders' Handbook. Kidder-Nolan.

Concrete Works. Hatt & Voss.

Design of Highway Bridges of Steel, Timber and Concrete. Ketchum.

Engineering Drawing. French.

Engineering Geology. Ries and Watson.

Fire Prevention and Fire Protection. Frietag.

Fresh-water Biology. Ward and Whipple.

Graphical Analysis. Wolfe.

Handbook of Hydraulics. King.

Mechanical Equipment of Buildings. Vol. 2. Harding & Willard.

Mechanics of Engineering. Church.

Materials of Construction. Johnson, Withey, Aston & Turneaure.

Practical Astronomy. Textbook. Hosmer.

Pumping Engines for Water Works. Hague.

Steel Mill Buildings. Ketchum.

Theory and Practice of Modern Framed Structures. 3 parts. Johnson, Bryan, Turneaure & Kinne.

Value for Rate-Making. Floy.

Waterworks Management and Maintenance. Hubbard and Kiersted.

LIBRARY COMMITTEE.

Vol. IX APRIL, 1922 No. 4

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPER IN THIS NUMBER.

"Address at the Annual Meeting." Robert Spurr Weston.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, March 15, 1922. — The seventy-fourth annual meeting of the Boston Society of Civil Engineers was called to order at 5.15 o'clock P.M. at the Boston City Club, by the President, Robert Spurr Weston.

The records of the meetings of February 15 and 28 were read and approved.

The President announced that the Board of Government had elected the following to membership in the grades named:

Members — Messrs. Arthur D. Dickson, William H. Fowler, George H. P. Gannon, Samuel Hobbs and J. Merrill Hanley.

Juniors — Mr. Henry M. Wilkins.

The President announced that the result of the letter ballot on the question of passing the resolution to join the Affiliation of

Technical Societies showed that 265 members were in favor thereof and 6 opposed, and that the resolution was therefore carried.

The President also announced that the result of the letter ballot endorsing a bill before Congress providing that Engineers in the Public Health Service should be commissioned showed that 228 members voted in favor and 13 opposed, and therefore the Society endorsed the bill.

The Annual reports were then taken up.

The President read the annual report of the Board of Government which was accepted and placed on file.

The reports of the Treasurer, Secretary, Librarian, Committee on Licensing Engineers, and Social Activities were read and on motion of Col. Gunby it was voted that these annual reports be accepted, recommendations adopted and be printed in the JOURNAL.

On motion of Past President Hodgdon it was voted that the incoming Board of Government be authorized to appoint such committees as it deems best.

The tellers of election presented their report of the election and in accordance therewith the President announced that the following officers had been elected for the ensuing year:

President — Dugald C. Jackson.
Vice-President (for two years) — Charles M. Allen.
Secretary — John B. Babcock, 3rd.
Treasurer — Frank C. Whitney.
Directors (for two years) — Herbert N. Cheney and Frank A. Marston.
Members of Nominating Committee (for two years) — Bertram Brewer, George A. Sampson and Henry A. Varney.

The President announced that the Desmond FitzGerald Medal for the year had been awarded to Mr. Harold K. Barrows for his paper on "Water-Power Development in New England."

The President announced that the Board of Government had awarded a copy of "Frontinus and the Water Supply of Rome" to Past President Charles R. Gow, for his paper on "The Responsibility of Organized Labor for the Stagnation in

the Building Industry." A copy of this book will be awarded annually in accordance with a gift of Mr. Clemens Herschel.

The President then delivered his annual address on "Some Engineering Practices and Ideals" which will be printed in the April JOURNAL.

The Business meeting thereupon adjourned and the members attended the supper and entertainment provided by the Social Activities Committee.

There were 163 members and guests present.

Adjourned at 10.30 P.M.

RICHARD K. HALE, *Acting Secretary.*

ANNUAL MEETING OF THE DESIGNERS SECTION.

BOSTON, March 8, 1922. — The Annual Meeting of the Designers Section was called to order at 6.05 P.M. by the Chairman, Ralph E. Rice. There were 16 members present.

The annual report of the Executive Committee was read and accepted.

The minutes of the previous meeting were read and approved. The report of the Nominating Committee was then read and by unanimous vote of the Section one ballot was cast electing the following officers nominated.

Chairman — Arthur L. Shaw.
Vice-Chairman — Howard C. Thomas.
Clerk — Waldo F. Pike.
Executive Committee —
Ralph E. Rice.
Walter W. Clifford.
John J. Harty, Jr.

After a few words by the retiring Chairman, the new Chairman, Mr. Arthur L. Shaw, assumed his office.

The first speaker of the evening was Mr. L. W. Marsh of the Johns-Manville Company. Mr. Marsh gave a very interesting talk on "Roof Coverings" beginning with the primitive thatched roofs and ending with the modern asbestos felt saturated with

asphalt. Samples were shown and methods of laying the roofing were shown with the lantern.

The next speaker was Mr. Fred Murtfeldt, of the W. A. Murtfeldt Company. Mr. Murtfeldt spoke from the standpoint of a practical roofer with many years of experience. He spoke in a general way of the advantages and disadvantages of various types of roofing and illustrated part of his talk with the lantern.

The meeting was adjourned at 8.35 P.M.

WALDO F. PIKE, *Clerk.*

ANNUAL REPORTS.

REPORT OF THE BOARD OF GOVERNMENT FOR THE YEAR 1921–1922.

BOSTON, March 15, 1922.

To the Boston Society Civil Engineers:

Pursuant to the requirements of the Constitution, the Board of Government presents its report for the year ending March 15, 1922.

Membership.

During the year 27 members have resigned, 35 have forfeited membership for non-payment of dues, 6 juniors have lost membership because of age limit, and 10 have died, making the total deductions 78.

One hundred members in all grades have been added during the year, of whom 3 were former members reinstated, and 2 juniors and 1 associate have been transferred to the grade of member.

The present membership of the Society consists of 7 honorary members, 779 members, 83 juniors, 28 associate, and 5 who are members of the Sanitary Section only, making a total membership of 902.

Deaths.

The loss by death during the year has been 10, as follows: —

John F. Monaghan, April 18, 1921.
S. Everett Tinkham, April 21, 1921.
Frank J. Nowell, May 25, 1921.
Richard Hutchinson, June 15, 1921.
Roy C. Aiken, June 24, 1921.
Herbert C. Bacon, August 27, 1921.
Charles E. Haberstroh, September 25, 1921.
Hiram F. Mills, October 4, 1921.
William E. Baker, November 7, 1921.
Charles A. Pearson, December 11, 1921

Remission of Dues.

Under authority of By-Law 8, the Board of Government has remitted the dues of 7 members.

Regular Meetings.

Eight regular meetings, one adjourned meeting, one special and two joint meetings have been held during the year, and an inspection trip to Watertown Arsenal and Outing at Norumbega Park which took the place of the regular meeting in the month of June.

The average attendance at these meetings was 95, the largest being 300, and the smallest 33.

At these meetings papers and addresses have been given, or special discussions held, as follows:

March 16, 1921. — Address of the retiring President, Frank A. Barbour, "The Engineer in the Service of the Public."

March 24, 1921. — Special meeting. Col. Charles R. Gow, "Responsibility of Organized Labor for the Present Stagnation in the Building Industry."

April 20, 1921. — Mr. Walter E. Spear, "Public Works in Modern Greece." Illustrated by lantern slides.

May 18, 1921. — Regular meeting. Not a quorum present. Adjourned.

May 25, 1921. — Adjourned meeting. Mr. Desmond FitzGerald, "Something about the Canyons of Utah," illustrated by lantern slides.

September 21, 1921. — Tinkham Memorial meeting. J. K. Berry, Esq., "Mr. Tinkham's Masonic Career." Past President, Frederic H. Fay, "Mr. Tinkham's Career as an Engineer." Past President, Edward E. Howe, "Mr. Tinkham's Personal Life while a Young Man." Past President, Desmond FitzGerald, "Mr. Tinkham's Conection with the Boston Society."

October 19, 1921. — Mr. George C. Danforth, Chief Engineer of the Maine Water Power Commission, "The Federal Water Power Act."

November 16, 1921. — Discussion, "Labor Problems of Today," by James Gauld, Carpenters' District Council; E. A. Johnson, Secretary, Building Trades Council.

The following gentlemen took part: William Stanley Parker, Architect; Morton C. Tuttle, Aberthaw Construction Co.; Charles R. Gow, Charles R. Gow Co.

December 21, 1921. — Mr. Arthur W. Dean, Chief Engineer, Division of Highways of the Public Works Department, Commonwealth of Massachusetts, "Highway Construction in Massachusetts."

Discussion opened by Mr. John R. Rablin, Chief Engineer Park Division, Metropolitan Park Commission.

January 25, 1921. — Mr. Thomas C. Atwood, of the T. C. Atwood Organization, of Raleigh, N. C., "Special Methods of Handling Cost-Plus Work for a Southern University."

February 15, 1922. — First Joint meeting, with the American Society of Mechanical Engineers and the American Institute of Electrical Engineers. Mr. Gerrit Fort, Vice-President of the Boston & Maine Railroad, "Problems of Freight Transportation in New England"; and Mr. Benjamin Franklin Fitch, of the Motor Terminals Company, of New York, "Coördination by the Unit Container System by the Railways, Waterways, Highways and Traction Lines for a relief of New England Transportation."

February 28, 1922. — Second Joint meeting. Hon. John N. Cole, Commissioner of Public Works, Commonwealth of Massachusetts, "Problems due to the Growth of the Motor Truck as a Freight Carrier"; and Prof. W. K. Hatt, Director of the Advisory Board on Highway Research, "General Situation in Highway Transport and the Need of Research in that Field."

Sanitary Section Meetings.

The Sanitary Section has held four meetings during the year. The following papers have been presented before this body:

March 2, 1921. — Report of Committee on "Methods of Design and Construction and Results of Operation of Inverted Syphons for carrying Sewage only and for Storm Water", Prof. Dwight Porter.

Also report of Committee on "Proposed Rules and Regulations of the Special Plumbing Board."

October 5, 1921. — "Rain-Fall and Run-Off from the Storms of June 28-July 2, and July 9 to 11, 1921."

Discussion opened by Mr. Frank A. Marston, of Metcalf & Eddy, Consulting Engineers.

December 7, 1921. — Mr. Ralph W. Loud, Assistant Engineer, Metropolitan Sewerage Works, "The Metropolitan Sewerage Works."

January 4, 1922. — Mr. J. Frederick Jackson, Director, and Mr. J. Doman, Asst. Engr., Connecticut State Department of Health, "Characteristics of some Connecticut Sludges."

The average attendance at these meetings was thirty-four.

Designers Section.

The Designers Section have held eight meetings during the year, with an average attendance of twenty-four.

The following papers have been presented:

March 9, 1922. — Prof. Edward H. Rockwell, of Tufts College, "A New Method of Designing Rigid Concrete Frames with Special Reference to Interior and Wall Columns."

April 13, 1921. — Mr. W. F. Gilcreast, of Waldo Bros. & Bond, and Mr. F. G. Ring, Director of Refining Engineering, "Construction of the Refinery of the New England Oil Corporation at Fall River."

May 11, 1921. — Mr. Henry C. Sheils, "Some Criticisms of Construction Specifications."

October 14, 1921. — Mr. Edward H. Cameron, of Jackson & Moreland, "Methods of Treating Turbine Foundations"; Vice-Chairman, Edwin S. Parker, "Design of the Foundations for the Great Press in the new Post Building."

December 14, 1921. — Prof. George F. Swain, "Earth Pressure."

January 11, 1922. — Mr. A. C. Bartlett, Ventilating Engineer, and Secretary of the Boston Chapter of the A. S. H. & V. E., "What is Ventilation?" Mr. F. A. Alden, Member, A.S.M.E., and Sales Manager for the Pierce, Butler & Pierce Manufacturing Corporation, "Practical Design and Installation of Heating and Ventilating Equipment."

Permanent Fund.

Owing to the prevailing high prices the Society at the October meeting authorized the Board of Government to use the income from the Permanent Fund to meet current expenses to such an extent as they deemed necessary.

Notification has been received that Hiram F. Mills, who died October 4, 1921, left the Society one thousand dollars, but no details in regard to the conditions of the bequest have been announced.

Tinkham Memorial Fund.

The Committee on a Memorial to Samuel Everett Tinkham reported to the Board of Government on September 21, 1921, recommending the creation of a fund for a scholarship or fellowship in research work to be known as the "S. E. Tinkham Memorial Fund." The report was accepted and contributions asked for. It is hoped that $6 000 will be raised.

The standing of these funds will be found in the report of the Treasurer.

Journal.

The report of the editor of the JOURNAL for the calendar year 1921 shows that there have been printed ten issues of 1250 copies each, comprising 674 pages. The net cost of the JOURNAL was $3 537.91 or $5.25 per page.

In 1920 the net cost was $2 944.95 or $4.71 per page, there being 625 pages.

The cost of printing has remained at a high level during the year but it is expected that it will be reduced during 1922.

Award of the Desmond FitzGerald Medal.

In accordance with the recommendations of the Committee appointed to award the medal for the best paper by a member of the Society, published during the year ending September, 1921, the Board has awarded the medal to Harold K. Barrows for his paper entitled "Water Power Development in New England." which was published in the January, 1921, JOURNAL.

The Federated American Engineering Societies.

On March 15, 1921, the Society voted to join the Federated American Engineering Societies, with the understanding that the cost of membership should be defrayed by voluntary subscription. So far 180 members have contributed $439.70 leaving a deficit of $388.51.

The amount collected averaged $2.44 per contributor, but only 55 cents per member, — i.e., one fifth of the membership contributed more than one half of the necessary amount. Membership in the Federation costs $1 per member per year, and the Board of Government believes that the new organization is necessary both for the individual engineer and the public, and that it is the duty and privilege of this Society to support its work. A Committee has been appointed to solicit subscriptions to meet the deficit, and it is hoped that, in the interests of democracy, its appeal will meet with a generous response from those who have not yet contributed.

On January 19, Mr. L. W. Wallace, Executive Secretary, appeared at a meeting of your Board of Government, and gave an authentic account of the accomplishments of the Federation, and of its plans for the future. It is planned that Dean M. E. Cooley, of the University of Michigan, who succeeded Herbert Hoover as President of the Federation, will visit Boston later in the year, and inform our Society further. He has just returned from a successful

visitation of the member societies in the west and southwest. Mr. Wallace succeeded in convincing his hearers, and we feel sure that Dean Cooley will convince every one that the Federation ought to be supported.

Inter-Society Relationship.

The most important and far reaching steps in the history of the Society have been taken this year towards a closer coöperation among all the Technical Societies of Boston.

At the June meeting the Society approved a change in the By-Laws which authorized the Board of Government to form affiliate sections. Under this provision the Northeastern Section of the American Society of Civil Engineers became in December the American Society of Civil Engineers Section.

The Northeastern Section of the American Society of Civil Engineers was organized on November 12, 1921, at a meeting held at the Boston City Club, at which time the Constitution and By-Laws were adopted, and the following officers elected:

Chairman — Frank B. Sanborn.
Vice-Chairman — Walter C. Voss.
Secretary-Treasurer — Charles W. Banks.
Executive Committee —
Leonard C. Wason and J. H. Manning.

The first regular meeting was held on January 28, 1922, at the Boston City Club with an attendance of 71.

The membership in this Section now numbers 65 which includes 22 who are not members of the Boston Society.

Under the same provision the Engineering Society of the Northeastern College became, on December 21, 1921, the Northeastern College Section of the Boston Society.

During the year many meetings were held with representatives of the several technical societies with the view of forming an affiliation for mutual benefit. These meetings culminated in the formation of a tentative constitution and by-laws which were submitted to the membership of all the societies during January.

This motion was unanimously adopted at the February meeting of the Society and submitted to the membership by letter ballot. The result of this ballot which has just been announced is a vote of 228 in favor of and 13 against the Society taking part in this movement.

Society Activities.

The high level at which prices have been maintained has been severely felt by the Society. The expenses have been increasing for several years faster than the income and this year, for the first time, there is a deficit in excess of the income from the Permanent Fund.

Such a condition, of course, cannot be maintained. It is essential if the Society is to maintain its position that the cost of operating the Society per member be reduced or that the income be increased. If neither of these can be done the activities of the Society must be reduced to bring the costs below the income.

Social Activities.

The Committee on Social Activities have continued their excellent programs and have provided light suppers in the Society rooms before the meetings. This has proved a very popular feature and has been well patronized by members.

For the Board of Government,

ROBERT SPURR WESTON, *President.*

REPORT OF THE TREASURER.

BOSTON, March 1, 1922.

To the Boston Society of Civil Engineers:

Your Treasurer presents the following report for the year ending March 1, 1922.

Detailed data are contained in the appended tabular statements; Table 1 gives the receipts and expenditures for the year; Table 2, Comparative Balance Sheets; Table 3, Investment of the Permanent Fund.

The current expenses for the year amount to $12 757.07 being $1 622.63 increase over the preceding year.

There has been transferred to the Current Fund from income for current Expenses carried over from last year $828.30 also all the income of the Permanent Fund for the current year, amounting to $2 355.00, a total of $3 183.30. The deficit of $720.41 includes $388.51 on account of membership in the Federated American Engineering Societies.

The net expense of the JOURNAL has been $422.71 more than last year. The income from advertisements decreased $7.50 and the sale of JOURNALS has been $120.15 less than last year, otherwise the JOURNAL expenses would show an increase of $295.06.

There has been an increase in the Permanent Fund of $750.00 after transferring the income for the current year of $2 355,00 to the Current Fund.

Ten Coöperative Bank Shares have been withdrawn, valued at $1 656.10.

Respectfully submitted,

F. O. WHITNEY, *Treasurer.*

Table I. — Receipts and Expenditures.

Current Fund.

Receipts.

Balance, March 1, 1921	$828.30
Members' Dues	7 001.93
Advertisements	1 153.00
Sale of Journals	158.07
Interest on Bank deposits	17.21
Furniture sold	49.50
Miscellaneous	33.95
Federation subscriptions	439.70
Income from Permanent Fund	2 355.00
	$12 036.66

Expenditures.

Journal	$4 771.28
Printing, stationery, postage, etc.	634.31
Rent (net)	2 524.96
Light	54.61
Salaries (except Editor)	2 695.00
Reporting	55.00
Stereopticon	21.00
Binding	130.65
Periodicals	172.15
Incidentals and Repairs	283.83
Insurance	35.30
Annual meeting and smoker	216.35
Social activities	127.11
Furnishing	54.15
Federated American Engineering Societies	828.21
Sanitary Section	73.29
Designers Section	36.35
Northeastern College Section	3.00
Northeastern Section	30.52
	$12 757.07
Deficit	720.41
	$12 036.66

Permanent Fund.

Receipts.

Balance March 1, 1921	$43.81
Entrance fees	650.00
Interest received (net)	1 880.50
Coöperative bank shares withdrawn	1 656.10
Contribution	100.00
	$4 330.41

Expenditures.

Coöperative bank dues	$760.00
3 shares Am. Tel. & Tel. Co. purchased	297.75
Income transferred to Current Funds	2 355.00
Balance	917.66
	$4 330.41

E. K. TURNER LIBRARY FUND.

Receipts.

Cash on hand March 1, 1921	$103.37
Interest on bond	50.00
	$153.37

Expenditures.

Books purchased	$64.10
Balance	89.27
	$153.37

TINKHAM MEMORIAL.

Receipts.

Contributions received	$1 965.50
Interest on bonds	35.00
	$2 000.50

Expenditures.

Portrait for library	$50.00
Bonds purchased	1 495.00
Accrued interest on bonds	41.39
Balance	414.11
	$2 000.50

TABLE 2. — COMPARATIVE BALANCE SHEETS.

Assets.	March 1, 1919.	March 1, 1920.	March 1, 1921.	March 1, 1922.
Cash	$487.12	$339.49	$975.48	**$286.52**
Bonds and notes	35 023.00	35 523.00	35 523.00	**35 523.00**
Stock	1 950.00	1 950.00	1 950.00	**2 247.75**
Coöperative banks	7 179.65	8 501.75	8 159.45	**7 737.85**
Library	7 500.00	7 500.00	7.500.00	7 500.00
Furniture	2 405.11	2 405.11	2 405.11	**2 405.11**
	$54 544.88	$56 213.35	$56 513.04	**$55 700.23**
Liabilities.				
Permanent Fund	$43 467.51	$43 852.51	$44 682.51	**$45 432.51**
E. K. Turner Fund	1 063.22	1 058.72	1 097.12	**1 083.02**
Unexpended appropriations	....	927.45	....	....
Current Funds	109.04	....	828.30	***720.41**
Unpaid bills	....	469.56	....	....
Surplus	9 905.11	9 905.11	9 905.11	**9 905.11**
	$54 544.88	$56 213.35	$56 513.04	**$55 700.23**

*Deficit.

TABLE 3. — INVESTMENT OF PERMANENT FUND, MARCH 1, 1922.

Bonds.	Par Value.	Actual Cost.	Value as carried on Books.
American Tel. & Tel. Co. Col. Tr. 4%, 1929	$3 000.00	$2 328.75	$2 737.50
Union Elec. Light & Power Co. 5%, 1932	2 000.00	2 050.00	2 050.00
Blackstone Valley Gas&Elec. Co. 5%, 1939	2 000.00	1 995.00	1 995.00
Dayton Gas Co. 5%, 1930	2 000.00	2 000.00	2 000.00
Milford & Uxbridge St. Ry. 7%, 1923	3 000.00	2 942.50	2 942.50
Railway & Light Securities Co. 5%, 1939	3 000.00	3 000.00	3 000.00
Superior Light & Power Co. 4%, 1931	4 000.00	3 347.50	3 347.50
Wheeling Electric Co. 5%, 1941	4 000.00	3 845.00	3 845.00
Economy Light & Power Co. 5%, 1956	1 000.00	990.00	990.00
Tampa Electric Co. 5%, 1933	2 000.00	2 000.00	2 000.00
Galveston Houston Elec. Ry. Co. 5%, 1954	2 000.00	1 940.00	1 940.00
Northern Texas Elec. Co. 5%, 1940	2 000.00	1 932.50	1 932.50
Chicago & Northwestern Ry. 5%, 1987	1 000.00	1 102.50	1 102.50
Vermont Power & Mfg. Co. 5%, 1928	1 000.00	965.00	965.00
American Tel. & Tel. Co. 5%, 1946	1 000.00	993.75	993.75
United States Liberty Loan 3½%, 1947	2 000.00	2 000.00	2 000.00
American Tel. & Tel. Co. 6%, 1925	200.00	188.00	188.00
United States Victory Loan, 4¾%, 1923	500.00	500.00	500.00
	$35 700.00	$34 120.50	$34 529.25
Stock.			
18 Shares Am. Tel. & Tel. Co.	1 800.00	2 247.75	2 247.75
Total securities	$37 500.00	$36 360.25	$36 777.00

Coöperative Banks.

15 shares Merchants Coöperative Bank, including interest to March	$1 997.00	
15 shares Volunteer Coöperative Bank, including interest to January	2 022.30	
25 shares Watertown Coöperative Bank including interest to March	3 718.55	7 737.85
Total value of invested funds		$44 514.85
Cash		917.66
		$45 432.51

E. K. Turner Fund.

Am. Tel. & Tel. Co. 5%, 1946	$1 000.00	$993.75	
Cash on hand	...	89.27	1 083.02
Total value of Permanent Funds			$46 515.53

Tinkham Memorial.

Connecticut Light & Power Co. 7%, 1951	1 000.00	1 020.00	1 020.00
Shawinigan Water & Power 6%, 1950	500.00	475.00	475.00
Cash			414.11
			$1 909.11

We have examined the above report and found it correct.

JOHN E. CARTY,
HENRY B. WOOD,

Auditing Committee of Directors of the Boston Society of Civil Engineers.

Report of the Acting Secretary.

Boston, March 1, 1922.

Richard K. Hale, Acting Secretary, ***in account with the*** Boston Society of Civil Engineers, *Dr.*

For cash received during the year ending March 1, 1922:

From entrance fees, new members and transfer:			
33 new members and associates	at $10,	$330.00	
62 juniors	at 5,	310.00	
2 juniors transferred to members	at 5,	10.00	
Total from entrance fees			$650.00
From annual dues for 1921–22, including dues from new members		$6 934.93	
From back dues		14.00	
From dues for 1922–23		53.00	
Total from dues			$7 001.93
From rents			2 055.00
From advertisements			1 153.00
From sale of Journals and reprints			158.07
From library fines			9.24
From sale of old paper			9.33
From telephone (N.E.W.W.A.)			14.21
From Engineers' Dinner refund			1.17
From sale of book cases			49.50
From contribution to building fund			100.00
From contributions towards Federation			439.70
From binding Journals			61.30
Total			$11 702.45

The above amount has been paid to the Treasurer, whose receipts the Acting Secretary holds.

Richard K. Hale, *Acting Secretary.*

We have examined the above report and found it correct.

John E. Carty,
Henry B. Wood,
Auditing Committee of Directors of the Boston Society of Civil Engineers.

REPORT OF THE LIBRARY COMMITTEE, 1921–22.

BOSTON, MASS., March 15, 1922

To the Boston Society of Civil Engineers:

The Librarian submits for the Library Committee the following report for the year 1921–1922:

Since the last report 132 bound volumes and 128 pamphlets have been added to the library making a total of 260 accessions. We now have a library of about 10 000 bound volumes and 3 400 pamphlets.

During the year 284 books have been loaned to members, and fines to the amount of $9.24 have been collected. In addition to this we have had an average of at least thirteen people per day come in to read or study so that we feel that our library has been very well used.

There have been inquiries of all kinds come in, both from members and non-members, for information on various lines, some of which could be readily answered and others required a good deal of research.

The Committee have purchased from the Turner Fund the following books on engineering subjects to be added to Section 10: "American Civil Engineers' Handbook," by Merriman; "Architects' and Builders' Handbook," by Kidder and Nolan; "Concrete Work," Vol. I., by Hatt and Voss; "Construction of Roads and Pavements," by Agg; "Design of Highway Bridges," by Ketchum; "Engineering Drawing," by French; "Engineering Geology," by Ries and Watson; "Fire Prevention and Fire Protection," by Frietag; "Fresh-Water Biology," by Ward and Whipple; "Graphical Analysis," by Wolfe; "Handbook of Hydraulics," by King; "Materials of Construction," by Johnson, Aston & Withey; "Mechanics of Engineering," by Church; "Method of Least Squares," by Merriman; "Mechanical Equipment of Buildings," Vol. 2, by Harding and Willard; "Modern Framed Structures," 3 volumes, by Johnson, Bryan and Turneaure; "Practical Astronomy," by Hosmer; "Pumping Engines for Water Works," by Hague; "Steel Mill Buildings," by Ketchum; "Waterworks Management and Maintenance," by Hubbard and Kiersted.

They have also ordered the following which will not be received in time to be included in the Treasurer's report this year:

"Value for Rate Making," by Floy; "Timber Framing," by Dewell; "Quebec Bridge Report," 2 vols., and Engineering News Index, Nos. 2, 3, 4 and 5.

The following books have been contributed by publishers and authors: "Collection and Disposal of Municipal Waste," by Greeley and Hering; "Concrete Designers' Manual," by Hool and Johnson; "Handbook of Construction Equipment," by Dana; "Location, Grading and Drainage of Highways," by Wilson and Harger; "Practical Least Squares," by Deland; "Sewerage and Sewage Disposal,'" by Metcalf and Eddy; "Waste in Industry," by Committee on Elimination, F.A.E.S.; "Boiler Code," "Heat Transfer", "Marine Steam", "Principles of Combustion,' and "Steam" by Babcock & Wilcox.

Gannett's "Geographic Tables and Formulæ," and Dunnack's "Maine Book," have been given by members of the Society, and Clemens Herschel has contributed the following to the Herschel Library: "American Engineers in France" by Parsons; "Further Incidents in the Life of a Mining Engineer" by MacCarthy; "Life of George Westinghouse" by Prout, and "Plan of New York State Barge Canal" for our general library.

It is hoped and expected that all our books will be so arranged as to be available for use during this next year. This work must necessarily be rather slow of accomplishment both on account of the study required to properly place them and on account of the many calls on the time of the assistant librarian.

The Catalogue Equipment and Supply Company have continued keeping up to date the collection of trade catalogs placed in our library, and pocket indexes to these catalogs will be furnished to members on request.

Respectfully submitted,

RICHARD K. HALE, *Librarian.*

REPORT OF THE EXECUTIVE COMMITTEE OF THE SANITARY SECTION.

BOSTON, MASS., March 1, 1922.

To the Sanitary Section, Boston Society of Civil Engineers:

During the past year four meetings were held, the subjects and speakers being as follows:

March 2, 1921. — Report of Committee on "Methods of Design and Construction, and Results of Operation of Inverted Siphons for Carrying Sewage Only and for Storm Water."

October 5, 1921. — "Rainfall and Run-Off from the Storms of June 28; July 2 and July 9 to 11, 1921." Discussion opened by Frank A. Marston.

December 7, 1921. — "Metropolitan Sewerage Works" by Ralph W. Loud.

January 4, 1922. — "Characteristics of Some Connecticut Sludges" by J. Frederick Jackson and Joseph Doman.

The attendance at the meetings has averaged 34 during the year.

The annual excursion was omitted this year and the Section joined the main Society in an outing to Norumbega Park.

Of the papers presented, two have been printed in the JOURNAL and it is hoped to obtain the manuscript for another.

There is now one special committee in the Section, the committee on Methods of Design and Construction and Results of Operation of Submerged Pipe Lines for Outfall Sewers. It is expected that this committee will make its final report at the annual meeting this year.

Five new members have been added during the year making the present total membership 198.

Respectfully submitted,

For the Executive Committee by

JOHN P. WENTWORTH, *Clerk.*

Report of the Executive Committee of the Designers Section.

Boston, March 1, 1922.

To the Designers Section of the Boston Society of Civil Engineers:

During the past year, eight regular meetings of the Designers Section have been held. The average attendance has been 24, and a large variety of subjects has been covered. The following list shows the dates of meetings, names of speakers and their subjects.

March 9, 1921. — Prof. E. H. Rockwell, "Methods of Designing Rigid Concrete Frames."

April 13, 1921. — Mr. W. F. Gilcreast, and Mr. F. G. Ring, "Construction and Operation of the Fall River Plant of the New England Oil Corporation."

May 11, 1921. — Mr. H. C. Sheils and Mr. J. E. Carty, "Some Criticisms of Construction Specifications."

October 14, 1921. — Mr. E. H. Cameron, "Steam Turbine Foundations;" and Mr. E. S. Parker, "The Boston Post Press Room Floor."

November 22, 1921. — Mr. E. D. Mortenson, "Design of Concrete Oil Tanks."

December 14, 1921. — Prof. G. F. Swain, "Earth Pressure."

January 11, 1922. — Mr. A. C. Bartlett and Mr. F. O. Alden, "Heating and Ventilating."

February 8, 1922. — Mr. O. A. Olstad, "Steel Forms."

The membership in the Section has increased to seventy-three during the year and an effort has been recently made by means of circulars, to interest new members of the Society in the activities of this Section.

Respectfully submitted,
For the Executive Committee, by

A. L. Shaw, *Clerk.*

Report of the Committee on Social Activities.

Boston, Mass., March 15, 1922.

To the Boston Society of Civil Engineers:

We beg to submit herewith our report on the Social Activities of the Society for the current year.

After careful consideration, and discussion with many of the members of the Society, it was decided to give up the customary all day joint outing which has been held for a number of years with the New England Water Works Association, and to substitute in its stead an afternoon trip of inspection through the Hood Rubber Company's factory and the Watertown Arsenal, followed by supper and a baseball game at Norumbega Park. The reasons for this decision were the absence of enthusiasm for the all day outing except

among those who were also members of the Water Works Association, the very small attendance at the recent outings by our members and the fact that many of the younger members could not afford to attend the all day meeting. Your committee met and discussed the matter with the committee of the Water Works Association, and the members of each Society were invited to attend both outings. Your committee believes that its action was approved as the attendance at the inspections was about one hundred and at the Park about forty.

Following the custom started two years ago light refreshments and cigars have been furnished preceding most of the regular meetings. We admit that on one night your Committee forgot to provide food. From the remarks that came back to the Committee following this oversight there can be little doubt but that the free meals are really looked forward to and enjoyed by a large number of members.

For the benefit of our successors in office we wish to recite a few of the difficulties met with in dispensing food and drink.

The post-war readjustment has proceeded so far that now sandwiches may be purchased for 8 cents each in bulk. Until we made this discovery we followed the example of our predecessors, buying about 8 lineal feet of bread per hundred persons to be fed, and then laboriously, with main strength and ignorance, manufacturing it into sandwiches. This was economical. Very few sandwiches were eaten. Unfortunately, however, after a meal served by last year's committee one of our respected members had to be carried out of the hall during the literary exercises of the evening, due to acute gastric distress. Having deep regard for the physical welfare of the members we finally abandoned the home-made product in favor of that manufactured by professionals.

The greatest difficulty your committee has encountered is that of estimating the appetites of the members. The first night the engineering society of the Northeastern College attended en masse, the food ran out long before the multitude was completely filled; and the night of the big snowstorm the ratio of sandwiches to participating members was exactly 8. We are discouraged. We give it up as a bad job.

Respectfully submitted,

(Signed) Scott Keith.
John M. Cashman.
Waldo F. Pike.
Erwin Harsch.
Harrison P. Eddy.

Report of Committee on Licensing Engineers.

Boston, Mass., March 15, 1922.

To the Board of Government, Boston Society of Civil Engineers:

Gentlemen, — The Joint Committee on Licensing Engineers was continued through the year ending March, 1922, with the same personnel representing the Boston Society of Civil Engineers as the previous year, and with authority, as before, to invite other engineering societies to authorize their representatives to continue or join with it, thereby being perpetuated as a joint committee. A schedule of the membership, with the changes in and additions thereto, is appended.

The Joint Committee has held two meetings during the year; the first on April 21, 1921, at which a majority report to the various member societies was prepared and signed by twelve of the thirteen members of the Committee, a copy of which is published in the Journal of the Boston Society of Civil Engineers for June, 1921, page 7*. The second meeting was held on September 13, 1921, to consider a circular letter sent out by the Executive Secretary of the Federated American Engineering Societies, requesting the attitude of engineers throughout the states as to licensing or registration, and inviting those interested to assist by presenting their views in writing or in person to the Committee on Licensing of the Federated American Engineering Societies at a meeting to be held by that committee in Chicago on September 19, 1921. The following letter was prepared by the Joint Committee and forwarded to the Executive Secretary of the Federated Societies, and was sent by him in turn to the meeting at Chicago:

Boston, Mass., September 13, 1921.

Mr. L. W. Wallace, Executive Secretary,
Federated American Engineering Societies,
719 *Fifteenth* Street, N.W., Washington, D.C.

Dear Sir:

At a meeting of the Joint Committee on the Licensing of Engineers, composed of fifteen representatives of ten of the principal engineering and architectural societies in Massachusetts, held this day, the following resolution was adopted:

"While it is the belief of this Committee that no benefit will accrue to the public if any laws licensing engineers are to be or have been passed, this Committee recommends to the forthcoming conference on licensing, to be held in Chicago on September 19, 1921, the advisability of requesting the American Engineering Council to consider the preparation of a uniform law for the licensing of engineers and to take such action as it deems advisable toward encouraging the general adoption of such a uniform law in those states which have already passed, or are about to pass an engineer's licensing law.

"This Committee further calls the attention of the American Engineering council to the report of the Joint Committee on Licensing Engineers in Massa-

chusetts, dated April 21, 1921, (a copy of which is appended) with particular reference to the general discussion and comments therein on the general principle and desirability of the licensing of engineers."

Very truly yours,

(Signed) EDWIN H. ROGERS,
Chairman, Joint Committee on Licensing of Engineers.

The licensing or registration of professional engineers has not been considered by the Massachusetts Legislature during the current session of 1922.

It is recommended that the Licensing Committee of the Boston Society of Civil Engineers be continued as before, with authority to continue its existence as a joint committee with representatives of other local engineering societies as a part of its membership.

Respectfully submitted,

EDWIN H. ROGERS,
Chairman, Joint Committee on Licensing of Engineers.

PERSONNEL OF JOINT COMMITTEE ON LICENSING OF ENGINEERS.

Representing Boston Society of Civil Engineers.

Charles T. Main,
Charles M. Spofford,
Charles R. Gow
Charles W. Sherman
Irving E. Moultrop
Edwin H. Rogers, *Chairman.*

Representing Boston Section, American Institute of Electrical Engineers.
Alexander Macomber
(vice Lewis W. Abbott)
from Sept. 9, 1921.

Representing Boston Section, American Society of Mechanical Engineers.
Arthur L. Williston

Representing Boston Society of Architects.
Clarence H. Blackall

Representing Boston Section, American Society of Heating & Ventilating Engrs.
Allen Hubbard

Representing Boston Section, American Inst. Mining & Metallurgical Engrs.
Edward E. Bugbee

Representing Boston Society of Landscape Architects.
Bremer W. Pond

Representing Northeastern Section, American Chemical Society.
Robert W. Neff
from April 21, 1921.

Representing Boston Chapter, American Association of Engineers.
Frank C. Shepherd
(vice Harry Sharpe)
from August 16, 1921.

Representing Engineering Society of Western Massachusetts.
Frederic H. Fay
from September 8, 1921.

Representing American Institute of Chemical Engineers.
Dr. Arthur D. Little
Robert Spurr Weston

Arthur L. Gardner
from October 21, 1921.

Representing Northeastern Section, American Society of Civil Engineers.
Burtis S. Brown
from December 13, 1921.

Report of Committee on Contractual Relations.

Boston, Mass., March 13, 1922.

To the Board of Government, Boston Society of Civil Engineers:

Gentlemen, — Your Committee appointed to consider and report upon eight important principles of contractual relations to be used in a standard contract document prepared as a part of the National movement inaugurated by Secretary Hoover, presents herewith as its report the report of a Joint Committee, which is the result of the combined efforts of your Committee and those of a similar Committee appointed by the President of the New England Water Works Association.

Yours very truly,

John L. Howard, *Chairman.*

Report of Joint Committee on Principles of Contractual Relations.

Boston, Mass., March 10, 1922.

The Joint Committee on Principles of Contractual Relations was formed by uniting the two committees appointed by the President of the Boston Society of Civil Engineers and the President of the New England Water Works Association, respectively.

The organization and membership of the Joint Committee is as follows:

Officers

Chairman, John L. Howard. Secretary, Frank A. Marston.

Members

Boston Society of Civil Engineers:
John L. Howard. Arthur C. Tozzer.
Frank B. Walker.

New England Water Works Association:
George A. Sampson. William G. Starkweather.
Frank A. Marston.

A national movement was started by Secretary Hoover of the Department of Commerce in December, 1921, looking toward the preparation of standard contract documents, which is worthy of the coöperative effort of all engineering societies. The conference called by Secretary Hoover, which was attended by representatives from nine of the national engineering societies, prepared outlines and appointed special subcommittees to undertake certain work looking forward to the standardization of construction contracts as far as possible, with the hope that such work would ultimately result in;—

1. Less expenditure for legal services in drawings proper contracts, and the elimination of disputes over contracts already drawn.
2. Less duplication of work in the profession attendant on construction.
3. Better safeguard for owners and increased public confidence.
4. An improved standard of construction service throughout the country.

The engineers, architects and contractors who approved this plan represented the following associations:

American Association of State Highway Officials,
American Engineering Council,
American Institute of Architects,
American Railway Engineering Association,
American Waterworks Association,
American Society of Civil Engineers,
Associated General Contractors of America,
National Association of Builders Exchanges,
Western Society of Engineers.

The work of this Joint Committee has been limited to a consideration and report upon the eight important principles of contractual relations prepared by a special committee working along the lines outlined by Secretary Hoover's conference.

These eight principles were published in " The Constructor ", which is the national publication of the Associated General Contractors, January 1922, page 19, as follows:

1. The award of contracts on a basis of skill, integrity and responsibility with the policy where practicable of eliminating irresponsible or inappropriate bidders before their proposals are received.
2. A satisfactory arbitration clause to be legally binding upon both parties.
3. A definite policy of inspection, with provision that if two or more separate interests are concerned in payment one authority shall act for all.
4. Specification of either the results to be obtained or the method to be followed, but not both.
5. Acceptance of work within a definite period after fulfillment of the contract, and as short a period of maintenance as is practicable.
6. Removal of responsibility from the contractor for contingencies beyond his control.
7. Reasonable limit upon the amount to which work under the contract can be increased or decreased.
8. Definite time and method of payment with provision for payment for materials delivered.

In considering these principles the Committee has felt that there were many other principles and questions which warranted careful study, as well as the eight outlined above, but because of limited time and because the work of the Committee was practically restricted to a consideration of these eight principles, study has not been given to the many other questions, some of them most perplexing, which would be involved in the complete study necessary for the preparation of standard contract documents.

It is believed that as a matter of general principle, contracts should be drawn so as to be as specific as possible, and specifications should be sufficiently complete when supplemented with detailed contract drawings, to make clear the amount and character of the work to be done, methods to be followed (where special methods are required) and all other details described, in sufficient clearness to prevent as far as possible misunderstanding, and to reduce to narrow limits the possibility of disputes and disagreements. It is felt that by these means much can be done to bring about more equitable conditions on construction work, from the viewpoint of the Owner, the Engineer and the Contractor.

A study of the eight principles above outlined, can only be made on a basis of broad interpretation. In public work, political conditions, existing statutes and other factors make it impracticable to follow out some of these principles.

Therefore, in interpreting the principles which are endorsed by this Committee in the following paragraphs, it should be borne in mind that the intention is that they are to be considered only on a broad basis, for adoption where conditions permit; that they cannot be taken literally in all cases; and that every construction contract, cannot be written to include all of the principles. Furthermore, there are other principles of equal importance which should be incorporated in the same way, and which should be given due weight

in writing a contract for construction work. The time available to this Committee for its work has not permitted a consideration of these other important factors, except indirectly as they may have had a bearing on the principles hereinafter stated.

With the general qualifications hereinbefore given, this Committee endorses the following principles of contractual relations: —

1. That proposals be invited only from responsible bidders; and that contracts be awarded with due regard to skill, integrity and experience.

2. (The conditions appertaining to different clases of work vary to such an extent that the Committee does not feel prepared to endorse the principle of arbitration for universal application, although recognizing its desirability in many cases.)

3. That if two or more separate interests are concerned, one authority shall act for all.

4. That as a matter of general principle, either the results to be obtained or the methods to be followed shall be specified, but not both where they would conflict.

5. That work be accepted within a definite period after the fulfilment of the contract; and that as short a period of maintenance be required, as is practicable.

6. That the contractor be relieved of certain responsibilities for specified contingencies beyond his control.

7. That where the character of the work will permit there should be a stated limit upon the amount to which work under the contract can be increased or decreased, due to a change in plan.

8. That there be a definite time for, and method of, payment; and that where practicable and advantageous there be provision for payment for certain specified materials delivered, for the safekeeping of which the contractor shall be responsible.

We submit this report with the recommendation that it be endorsed by the Boston Society of Civil Engineers and the New England Water Works Association, for the sake of coöperating in the national movement leading towards the preparation of standard contract documents, insofar as such a project is feasible.

Endorsements of these principles, or any action taken in regard to them, should be transmitted to Mr. W. P. Christie, Secretary of the Conference, Munsey Building, Washington, D.C.

We believe that it is possible to prepare a standard form of contract, including only such general clauses as would be applicable to all construction contracts, or perhaps to certain classes of construction contracts, so that the general procedure covered by such clauses will be standardized, to the great benefit of all parties concerned in construction work.

Respectfully submitted,

(Signed) JOHN L. HOWARD, *Chairman.*
ARTHUR C. TOZZER.
FRANK B. WALKER.
GEORGE A. SAMPSON.
WILLIAM G. STARKWEATHER, by F.W.M.
FRANK A. MARSTON, *Secretary.*

Report of the Editor.

To the Board of Government, Boston Society of Civil Engineers:

Gentlemen, — The Editor submits the following report for the calendar year 1921.

There have been published 16 papers and 7 memoirs of deceased members.

The 10 issues of the Journal of 1 250 copies each contained a total of 674 pages.

The net cost was $3 537.91, or $5.25 per page. In 1920 the net cost was $2 944.95 and the cost per page was $4.71. The increased cost was largely due to very expensive inserts in the September issue.

Printing costs for the coming year will be considerably less than in the past few years.

The amount of advertising matter carried was somewhat less than in 1920 but this source of revenue doubtless can be restored with a return of more normal industrial conditions.

In the appended table are shown, in tabular form, figures of cost, number of pages and other details.

Respectfully submitted,

W. L. Butcher, *Editor.*

1921 Journal.

Month	Pages of				No. of		Cost of							
	Papers	Proc.	Index.	Adv. (inc. Index and Other Unpaid Space).	Inserts.	Cuts.	Papers, Proc. and Index (inc. Stock for Adv. Pages).	Inserts and Cuts.	Adv.	Reprints.	Postage Wrapping and Mailing.	Editing.	Incidentals.	Copyright.
Jan.	52	14		19		10	480.11	$40.43	$39.00	$45.00	$30.79		$4.40	
Feb.	20	14		$18^{11}/_{12}$			252.27		31.25	23.50	27.14		5.00	
Mar.	50	8		17		13	415.50	51.82	43.45	53.00	37.64		.12	
Apr.	34	32		17			325.07		28.00	37.50	25.19			
May	46	8		17		8	366.04	43.86	27.25	43.50	27.15		5.00	
June	28	18		17		15	257.94	74.33	31.75	24.00	21.58			
Sept.	60	12		15	2	9	367.72	346.53	44.05	51.00	25.68		5.00	
Oct.	20	10		14½		1	179.29	6.60	55.05	24.09	29.10		.12	
Nov.	14	6		14½			142.26		26.50	16.58	22.52		50.00	
Dec.	28	8	8	14½			264.81		26.50		26.50			
	352	130	8	$164^{5}/_{12}$*	2	56	$3 051.01	$563.57	$352.80	$318.17	$273.29	$450.00	$69.64†	$10.00

* 184 pages used not all set solid.

† Includes $45 for wrappers for mailing purposes and $20 second class postage.

Gross cost		$5 088.48
Receipts, sales of Journals and subscriptions	$156.07	
Advertisement	1 336.00	
Reprints	58.50	1 550.57
Net cost		$3 537.91

APPLICATIONS FOR MEMBERSHIP.

April 15, 1922.

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

FAIR, GORDON M., Cleveland, O. (Age 28, b. Burghersdorp, So. Africa.) Educated at the Royal Technical College, Germany, Harvard University and Massachusetts Institute of Technology, and received the degree S.B. from the two latter. Served in the Canadian Army during 1916–17 after which he was engaged in research work on water purification for the R. U. V., also in New York City under supervision of George A. Johnson. In September 1918 he was appointed instructor in Sanitary Engineering in Harvard University during which time he was engaged in studies of water supply and sewage disposal as assistant to Prof. Whipple. In January 1921 he was appointed as assistant chief of the Division of Sanitation of the League of Red Cross Societies in Geneva, Switzerland. At present is Director of the Bureau of Statistics and Research of the Cuyahoga County Public Health Association in Cleveland, O. Refers to H. W. Green, A. Hazen, H. J. Hughes, C. M. Spofford, G. C. Whipple.

LOCKMAN, EDWARD LESLIE, Somerville, Mass. (Age 43, b. Lisbon, O.) He began railroad service with the Union Switch & Signal Co., in September, 1898; in the signal department of the N.Y., N.H. & H.R.R. from 1899–1901; signal maintainer with the Boston Elevated from 1901–1903; foreman of signal construction 1903–1905; general foreman signal department 1905–1912; assistant road master of rapid transit lines from March 1912 to December 1920, when he was appointed assistant engineer of surface lines in which work he is at present engaged. Refers to C. T. Fernald, H. C. Hartwell, A. T. Sprague, Jr. and H. M. Steward.

LIST OF MEMBERS.

ADDITIONS.

FLOOD, FRANK L. .... 431 Concord St., Framingham, Mass.
FOWLER, WILLIAM H. .... 176 East Foster St., Melrose, Mass.
HALE, HAROLD W., ... 166 St. Botolph St., Boston 17, Mass.
HANLEY, J. MERRILL .... 25 Austin St., Milton, Mass.
HOBBS, SAMUEL .... 7 Fairview Ave., Reading, Mass.
NYMAN, CHESTER L. .... 42 Church St., Marlboro, Mass.
OAKMAN, ROGER G. .... 41 Walnut St., Neponset, Mass.
PEARCE, HOWARD T. .... 166 St. Botolph St., Boston 17, Mass.
RUSSELL, JOHN B. .... 21 Eliot St., Quincy 69, Mass.
WILKINS, HENRY M. .... 23 Abbot St., Marblehead, Mass.
WILLIAMS, FREDERICK C. .... Wilson Dam, East Florence, Ala.

CHANGES OF ADDRESS.

CANNON, MADISON M. .... 161 Devonshire St., Boston, Mass.
DUFOUR, FRANK O. .... Lafayette College, Easton, Pa.
DURHAM, HENRY W. .... 2 Rector St., New York, N. Y.
EISNOR, JOHN J. .... 404 Highland Ave., West Somerville, Mass.
EMERSON, RALPH W. .... 18 Church St., Pittsfield, Mass.
HANNAN, WILLIAM E. .... 45 Edwin St., Dorchester, Mass.
LONG, WILLIAM J. .... Woonsocket, R. I.
McCORKINDALE, RALPH I. .... 116 Hubbard St., Ludlow, Mass.
NAWN, HUGH .... 82 Savin St., Roxbury, Mass.
NAWN, LEO J. .... 82 Savin St., Roxbury, Mass.
PERRY, CHAUNCY R. .... 73 Worcester Lane, Waltham, Mass.
PRICE, HERMAN S. .... U. S. Land Office, Santa Fè, N. M.
STEARNS, RALPH H. .... Room 1207, 8 West 40th St., New York, N. Y.
YOUNG, ERVING M., ... The Dawes House, Lawrenceville, N. J.

DEATHS

NELSON, WILLIAM .... March 13, 1922.
HOWE, WILL B. .... April 1, 1922.

RESIGNATIONS.

BANCROFT, LEWIS M.
BAYLEY, FRANK A.
BOURNE, FRANK B.
BRESTH, ALEXANDER
BROWN, ALBERT F.
CAIRD, A. WINTON.
CLARK, WILLIAM A.
DONOVAN, FREDERICK P.
EMERSON, GEORGE D.
ETTER, HAROLD P.
HATHAWAY, ERWIN O.
HASTIE, FRANK B.
JONES, FREDERICK E.
KIMBALL, HERBERT S.
MOODY, HERBERT A.
PUTNAM, HAROLD W.
RICH, MALCOLM
ROPES, HORACE,
ROSS, ELMER W.
SHAW, EDWARD W.
SHERMAN, EDWARD C.
SHUTE, GEORGE P.
SKILLIN, FRED B.
STRATTON, GEORGE E.
STROUT, HENRY E., Jr.
TREADWELL, EDWARD D.
WOOD, CARL W.

LIBRARY NOTES.

Book Review.

"Sewerage and Sewage Disposal." A Textbook by Leonard Metcalf and Harrison P. Eddy, First Edition. McGraw-Hill Book Company Inc., New York and London. Cloth, 6 x 9 in.; pp. 598; illustrated, $5.00.

Reviewed by Dwight Porter.*

This work is in response to a demand which has existed since the publication some seven or eight years ago of the three volumes devoted to "American Sewerage Practice" for an abridgement within a single volume for class use in engineering schools. There is a wide difference in the amount of time given to the general subject in various institutions, but the authors have sought to present the information "which they consider it desirable for the young student to acquire before taking up work in this field." Their long experience as sanitary engineers and their wide contact with teachers and with young graduates invite confidence in the soundness of their judgment in this matter. They have produced a book which should be ample for the needs of any undergraduate specialized course in sanitary engineering, and which by judicious use can be adapted to the briefer requirements of less highly specialized courses in civil engineering. It contains upwards of two hundred illustrations, mainly line drawings and diagrams, clearly drawn and fully lettered, many of them taken from the office practice of the authors.

The first half is given to sewerage, — general considerations governing sewer systems coming first, followed in turn by estimation of volume of sewage and of storm water, description of various sewer appurtenances and special structures, and three chapters relating to surveys, office work, materials, and the construction of sewers. These latter chapters are so largely concerned with details which, though of practical importance, would be of questionable service for class assignment, that they may be regarded as mainly useful for general purposes of re-

* Prof. Hydraulic Engineering, Mass. Inst. of Tech., Cambridge, Mass.

ference. Noticeably helpful features are a design worked out in detail for a separate system for an existing sewer district of between one and two hundred acres; later a design by the rational method for a storm-water system for the same district; a set of a dozen practical problems for applying hydraulic principles governing velocity of flow to special cases; and a solution worked out for the design of a multiple-pipe inverted siphon which occurred in the author's practice.

Sewage disposal is introduced by a chapter on the chemical and biological characteristics of sewage, explaining the meaning and significance of various analyses, of the nitrogen cycle, of putrescibility tests, giving outlines of standard laboratory methods, and so on. The balance of the book, with the exception of the final chapters, deals successively with disposal by dilution and with the different prominent methods of sewage treatment, with especial fulness in the case of trickling filters and the activated sludge process. The purpose of the authors has obviously been not merely to describe in a general way treatment processes, but also to add data, practical instructions and suggestions which should lend themselves to the actual design of works. Their extended experiences as designing engineers of such projects fits them admirably to do this. Evidence of this purpose is general through the chapters under consideration, but attention may be called specifically to articles on the design of grit chambers, of horizontal-flow tanks, of chemical precipitation tanks, and of siphonic dosing apparatus for trickling filters.

General methods of estimating cost are explained in the final chapter, which will be much appreciated by students. The volume here noticed in outline is characterized by simple, common sense statements of underlying principles, logical arrangement in their application, and clearness of expression. It furnishes an addition of great and enduring value to the literature of sanitary engineering, and for it gratitude is due alike from engineers, teachers and students.

Recent Additions to the Library.

U. S. Government Reports.

Mortality Statistics. Bulletin 148.

Municipal Reports.

Belmont, Mass. Annual Report Water Commissioners. 1921.

Boston, Mass. Annual Report Public Works Dept. 1920.

Brookline, Mass. Annual Report Town Engineers. 1921.

Brookline, Mass. Annual Report Water Board. 1921.

Detroit, Mich. Annual Report Board of Water Commissioners. 1921.

Dover, N. H. Annual Report Board of Water Commissioners. 1921.

Framingham, Mass. Annual Report Board of Water Commissioners. 1921.

Hartford, Conn. Annual Report Board of Water Commissioners. 1920.

Haverhill, Mass. Annual Report Board of Water Commissioners. 1921.

Reading, Mass. Annual Report Board of Public Works. 1921.

Rutland, Vt. Annual Report City Government. 1921.

County Reports.

Essex County. Annual Report of the Engineer. 1921.

State Reports.

New York. Annual Report of Board of Health. Vol. 2. 1920.

Miscellaneous.

Engineering News Index. 4 Vols. 1890–1917.

Theory of Framed Structures. Ellis. Gift of McGraw-Hill.

Quebec Bridge Report. 2 Vols. Monsarrat.

Library Committee.

Vol. IX · MAY, 1922 No. 5

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPER IN THIS NUMBER.

"The Engineer in the Tropics." T. Howard Barnes.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, April 26, 1922. — An adjourned meeting of the Boston Society of Civil Engineers was held this evening in Gilbert Hall, Tremont Temple. The meeting was called to order at 7.45 P.M., by the President, Dugald C. Jackson. This meeting was a joint meeting of the Boston Society of Civil Engieers and the Northeastern Section of the American Society of Civil Engineers.

There were 75 members and guests present.

The reading of the minutes of the Annual Meeting was dispensed with since they are printed in the April JOURNAL.

The Secretary reported for the Board of Government the names of those elected to membership in the grades named:

Members — Messrs. Harold F. Davis,* Albert C. Dove, Harrison P. Eddy, Jr.*, and Charles L. Crosier.*

* Indicates transfer from grade of Junior to Member.

Juniors — Messrs. Ovidio D. Chiesa and Frederick J. Randlett.

Associates — Messrs. William A. Connolly and James R. Gibson.

The President announced the death of the following members:

Mr. William Nelson, who died March 13, 1922,
Mr. Will B. Howe, who died April 1, 1922,
Mr. Andrew M. Lovis, who died April 25, 1922.

It was voted that the President appoint Committees to prepare memoirs of these members. The Committee appointed for William Nelson consists of Messrs. C. A. French and Prof. C. Frank Allen. The Committee for Will B. Howe consists of Messrs. W. H. G. Mann and F. W. Lang. The Committee for Andrew M. Lovis consists of Messrs. Arthur W. Dean and John R. Rablin.

The President announced that under authority of a vote of the Society the following committees had been appointed:

On Approving Applications for Membership: The Secretary, the two Vice-Presidents, and in case of the absence of any one of these three, the Treasurer to act as alternate.

On Investment: The President, the Senior Vice-President and the Treasurer.

On Publication: Harold K. Barrows, Chairman, Edgar S. Dorr and Henry B. Wood.

On Papers and Program: Dugald C. Jackson, Chairman, John B. Babcock, 3d, Herbert N. Cheney, Herbert S. Cleverdon, Richard K. Hale, Frank M. Gunby, J. H. Manning and Frank A. Marston.

On the Library: J. B. Babcock, Chairman, Dwight Porter and Edward H. Cameron.

On Social Activities: Erwin Harsch, Chairman, Frank L. Flood, Kenneth C. Reynolds, Howard C. Thomas and Walter A. Woods.

On Legislative Matters: Henry F. Bryant, Chairman, Hartley L. White, Charles B. Breed, Frank O. Whitney and Sturgis H. Thorndike.

On Licensing of Engineers: Edwin H. Rogers, Chairman, Charles T. Main, Charles W. Sherman, Irving E. Moultrop and Charles M. Spofford.

On Run-Off: Arthur T. Safford, Chairman, Harold S. Boardman, Arthur C. Eaton, X. Henry Goodnough, Richard A. Hale, Charles H. Pierce, Walter H. Sawyer, Charles W. Sherman, William F. Uhl, Frank E. Winsor, Dana M. Wood and S. Stanley Kent.

On Sub-Soils of Boston: Harry E. Sawtell, Chairman, Henry S. Adams, Charles D. Kirkpatrick and Frank M. Gunby.

On Tinkham Memorial: Edward W. Howe, Chairman, Desmond FitzGerald, Edgar S. Dorr, Frederick H. Fay and John E. Carty.

On Membership: John E. L. Monaghan, Chairman, Arthur B. Appleton, George S. Coleman, Carl S. Ell, Frank C. Shepherd, Warren D. Trask, John P. Wentworth and Dana M. Wood.

On Welfare: Lewis E. Moore, Chairman, David A. Ambrose, Charles R. Berry, John E. Carty, Pusey Jones, Beardsley Lawrence and John F. Osborn.

Prof. Jackson introduced Mr. Frank B. Sanborn, Chairman of the Northeastern Section, American Society of Civil Engineers, who conducted the literary program.

It was voted by the members of the Northeastern Section that the next meeting of the Section would be held on Saturday, June 3, 1922, instead of having the regular May meeting.

The subject of the meeting was Universal Form of Contracts.

General William H. Rose, Director of Lockwood, Greene & Company and Manager of the New York Office, discussed the general principles involved in the Universal Form of Contract.

The following speakers were then introduced who discussed this subject:

Mr. Wm. Stanley Parker, F. A. I. A., Chairman of the American Institute of Architects Committee on Contracts, and Member of the Joint Conference on Standard Contract Forms, discussed the paper from the architect's viewpoint;

Mr. Arthur W. Dean, Chief Engineer, Division of Highways, Department of Public Works, Commonwealth of Massachusetts, spoke from experience in municipal and public works;

Mr. J. Parker Snow, Consulting Engineer, Boston, from the railroad point of view;

Col. Frank M. Gunby, Engineering Manager for Charles T. Main, Engineer, Boston, from an industrial engineer's viewpoint;

Mr. Arthur C. Tozzer, Vice-President and New England Manager of Turner Construction Company, from that of the contractors.

The subject was then informally discussed by the following: Prof. Charles M. Spofford, Prof. C. Frank Allen, Leonard C. Wason, Mr. Nelson of the firm of Jackson & Moreland and E. S. Larned. Concluding remarks were made by Mr. J. P. Snow, Mr. Parker and General Rose.

Upon the motion of Professor Allen a vote of thanks was tendered to those who participated in the meeting and who are not members of the Boston Society of Civil Engineers or of the Northeastern Section, American Society of Civil Engineers.

Adjourned at 10.20 P.M.

J. B. BABCOCK, *Secretary.*

BOSTON, April 12, 1922. — The regular April meeting of the Designers Section of the Boston Society of Civil Engineers was called to order at 6.10 P.M., by Chairman Arthur L. Shaw.

There were 24 members and guests present.

The minutes of the previous meeting were read and accepted.

Mr. John W. Raymond, Jr., of the staff of Metcalf & Eddy, gave a very interesting and complete talk on "Some Features of Sewer Design."

A short discussion followed.

Meeting adjourned at 7.20 P.M.

W. F. PIKE, *Clerk.*

BOSTON, March 10, 1922. — A regular meeting of the Northeastern College Section of the Boston Society of Civil Engineers was held this evening at the Society Rooms, Tremont Temple.

The meeting was called to order by the Chairman, Mr. Edwin C. Williams, at 7.50 P.M.

The minutes of the previous meeting were read and accepted.

Mr. Frank L. Flood explained and read in detail the Constitution and By-Laws of the Section, as formulated by the Executive Committee.

Motion was made and seconded that no dues other than those due to the Boston Society of Civil Engineers be assessed any member of the Section. The motion was passed.

Prof. Henry B. Alvord, of Northeastern College, gave an instructive talk on "The Relation between Plane Rectangular Coördinates and Geographic Positions."

Meeting adjourned.

KARL H. AIMO, *Clerk.*

APPLICATIONS FOR MEMBERSHIP.

[May 17, 1922.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

HAGEMAN, HARRY ANDREW, Newton Hlds., Mass. (Age 45, b. Niagara Falls, N. Y.) Graduate of Niagara Falls High School in 1893, and of Cornell University in Mechanical Engineering in 1899. During the summer of 1895–96 and from 1897–98 he was draftsman and designer on hydro-electric work for Niagara Falls Power Co.; 1899–1901, designer and field representative on hydro-electric work at Trenton Falls, N. Y., with W. A. Brackenridge, Consulting Engineer; 1901–5 draftsman and inspector for Niagara Falls Power Co., and its allied companies; 1906–7 assistant hydraulic engineer, with I. P.

Morris Co., Philadelphia, Pa., turbine manufacturers; 1907–9 mechanical engineer for operating dept., Niagara Falls Power Co., Canadian Niagara Power Co., and Niagara Junction Railway Co.; 1910–14 in charge of hydraulic department with Stone & Webster at their Seattle, Wash., and Fresno, Cal., offices, on design of White River development, Snoqualmie Falls development, Big Creek and White Salmon development (advisory capacity); 1914–17 engineer, hydraulic division, Stone & Webster, Boston office; 1917–1921 mechanical engineer in charge of design and construction of plant, Bethlehem Shipbuilding Corp., Ltd., Bethlehem, Pa.; 1921 to date hydraulic engineer, Stone & Webster, Boston. Refers to W. N. Patten, C. R. Main, J. H. Manning J. F. Vaughan, D. M. Wood.

McCann, George F., Jersey City, N. J. (Age 24, b. Lowell, Mass.) Graduated from Villanova College, Villanova, Pa., with the degree of B.S. in civil engineering in 1920, since which time has been employed by Thomas Murray, Inc., as designing and constructing engineer on the construction of Hell Gate Station of the United Electric Light and Power Co. In this work he conducted preliminary surveys, located lines and apparatus, supervised pouring of concrete, and was designing in the field office; at present is computing final quantity estimate of material used in the construction of the station. Refers to W. E. Boyd, F. J. McCann, J. J. Meagher, W. D. Morrill.

LIST OF MEMBERS.

ADDITIONS.

Gibson, James R.,........................65 Long Wharf, Boston, Mass.

CHANGES OF ADDRESS.

Bigelow, W. W.......................... 141 Milk St., Boston, Mass.
Burrage, Henry T...................... 67 Nolan St., Stratford, Conn.
Casey, John J.......................... 7 Louise Park, Roxbury, Mass.
Conger, Alger A.................... 13 St. Elmo Rd., Worcester, Mass.
Knowles, Morris............... 318 Westinghouse Bldg., Pittsburgh, Pa.
Reynolds, Kenneth C.,.......... Mass. Inst. of Tech., Cambridge, Mass.
Richards, Walter C.,..... Box 31, Shawsheen Village Sta., Andover, Mass.
Smith, Sidney...................... 75 Corey St., West Roxbury, Mass.
Thomas, Howard C.,................ 100 Floral St., Newton Hlds., Mass.
Tupper, Frederick E.,.................. Presidents Lane, Quincy, Mass.
Whitney, Ralph E.,............... 19 Hillside Rd., Newton Hlds., Mass.

DEATH.

Lovis, Andrew M.,.................................... April 25, 1922.

LIBRARY NOTES.

Book Review.

Essentials in the Theory of Framed Structures: By Charles A. Ellis, A.B. Vice-President, The Strauss Bascule Bridge Co.; with American Bridge Company 1901–1908. Asst. Professor of Civil Engineering, University of Michigan 1908–1912. Designing engineer Dominion Bridge Company 1912–1914. Professor of Structural Engineering, University of Illinois 1914–1921. First edition. New York, McGraw-Hill Book Co. 330 pp. Figures and tables.

Reviewed by Lewis E. Moore.*

This is essentially a text book and differs from ordinary texts in that the author follows a different order. Instead of developing generalities and formulas and then making particular applications, he begins with illustrative examples, and reasons about them, and from them deduces the general principles.

The first part is devoted to the conditions of equilibrium of co-planar forces and afterwards these principles are applied to the determination of stresses in trusses and in beams.

In the material on roof trusses the lack of standard practices is pointed out and considerable attention is paid to the uncertainties involved in this type of construction. No attempt is made to give solutions which are any more accurate than the uncertainties involved in the solution warrant.

The method of influence lines is used extensively in finding maximum stresses.

The chapter on the deflection of beams uses almost wholly the so-called area-moment method, which is much more powerful than the elastic curve method and is also much simpler in its application.

No treatment of statically indeterminate structures is given other than the chapter on restrained, continuous and partially continuous beams.

The deflection of trusses is treated and also the case of the swing bridge.

The book is quite novel in its method of approach to the subject and is intended to develop a student's ability to think rather than to present facts or formulas to memorize. It should prove useful, especially to the experienced teacher.

* Consulting Engineer, 1149 Tremont Bldg., Boston, Mass.

Recent Additions to the Library.

U. S. Government Reports.

Bulletin 983, U. S. Dept. of Agriculture.

Annual Report of the Weather Bureau. U. S. Dept. of Agriculture.

Municipal Reports.

Burlington, Vt. Annual Report Water Department, 1921.

Danvers, Mass. Annual Report Water Commissioners. 1921.

Holyoke, Mass. Board of Water Commissioners. 1921.

Laconia, N. H. Annual Report Public Works Department 1921.

Northampton, Mass. Annual Report Water Commissioners. 1921.

Plymouth, Mass. Annual Report Water Commissioners. 1921.

Springfield, Mass. Annual Report Water Commissioners. 1921.

Wellesley, Mass. Annual Report Water Commissioners. 1921.

State Reports.

Connecticut. Annual Report Department of Public Works. 1921.

Massachusetts. Annual Report Department of Public Works. 1920.

New Jersey. Annual Report Department of Conservation and Development. 1921.

Miscellaneous.

Engineering Index. 1921.

Overhead Systems. National Electric Light Association. Report.

Prime Movers. National Electric Light Association. Report.

Proceedings of Institution of Civil Engineers. Vol, 211. Part 1.

Report of Mines Branch, Canada. 1920.

Library Committee.

Vol. IX JUNE, 1922 No. 6

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER

"What shall be Done to Secure Better City Planning?" By Geo. H. Nye.

Memoirs of Deceased Members.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, May 17, 1922. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 7.45 P.M., by the Senior Vice-President, Mr. E. H. Rogers.

There were 130 members and guests present.

The minutes of the last meeting were read and approved.

The Secretary reported for the Board of Government the names of those elected to membership in the grade of Member:

Members — Messrs. Gordon M. Fair* and Edward L. Lockman.

The Chairman announced that a convention was to be held by the American Society of Civil Engineers at Portsmouth,

* Indicates transfer from grade of Junior to Member.

N. H., on Wednesday and Thursday, June 21 and 22. In accordance with the By-Laws a regular meeting of the Boston Society would be held on Wednesday, June 21, unless otherwise provided. On motion of Mr. Whitney it was voted that the regular June meeting of the Society be omitted.

The Chairman announced that the Board of Government had authorized the Committee on Social Activities to determine whether or not an outing should be held in June, and to select a date.

The report of the Committee consisting of Messrs. F. S. Hart and F. I. Winslow, appointed to prepare a memoir of Charles E. Haberstroh, was presented. This report was accepted with the thanks of the Society and was ordered printed in the JOURNAL.

The subject of the meeting was " City Planning."

Mr. George H. Nye, City Engineer of New Bedford, presented a paper on the general subject of city planning, dealing with the present situation in regard to street development and including a discussion of ways and means to secure the scientific development of a satisfactory system of streets.

Mr. Arthur A. Shurtleff, Town Planner, gave an illustrated talk showing slides of various developments. Particular attention was given to the proposed plans for the City of Newton.

Miss Elizabeth M. Herlihy, Secretary of the Boston City Planning Board, described the comprehensive studies which are being made for the proper development of Boston.

Mr. John F. Fitzgerald, a former Mayor of Boston, spoke on city planning for Metropolitan Boston with particular reference to improved transportation facilities.

Mr. Desmond FitzGerald urged the study of civic centres in connection with city and town planning.

Mr. E. H Rogers, City Engineer of Newton, described the zoning regulations which are under consideration in that city.

Mr. F. O. Whitney, Chief Engineer of the Street Laying Out Department, City of Boston, told of the work of the Board of Survey.

Mr. Morris Knowles, of Pittsburgh, described the work done in connection with zoning by Secretary Hoover.

Mr. R. A. Hale described briefly the important work of Mr. Charles H. Storrow in the early development of streets in Lawrence, Mass.

Upon motion of Mr. F. O. Whitney, a vote of thanks was extended to those, not members of the Society, who had participated in the meeting.

Adjourned 10.10 P.M.

J. B. BABCOCK, *Secretary.*

BOSTON, May 19, 1922. — The first Annual Meeting of the Northeastern University Section of the Boston Society of Civil Engineers was held this evening in Room 303, Gainsboro Building, Boston.

The meeting was called to order by Vice-Chairman E. S. Parsons, at 7.30 o'clock. There were 15 members present.

Minutes of the previous meeting were read and accepted.

The adoption of the Constitution and By-Laws of the Section was then taken up. Motion made and seconded that Article II, Section 2, be changed to read as follows: "Members and Junior members only shall be entitled to the right to vote." Motion was passed. Motion was made and seconded that an additional section be made to Article II, Section 3 to read as follows: "Members and Junior members only of this Section who are students at Northeastern University are eligible to hold office." Motion was passed. No other changes were made, then the Constitution and By-Laws of the Section were accepted by a unanimous vote.

The following members were elected as officers:

Chairman — D. C. Milne.
Vice-Chairman — Henry Brask.
Clerk — A. O. Bradshaw.
Executive Committee —
K. H. Aimo.
A. S. Dawe,
Benjamin Rubin.

Meeting adjourned at 9.00 o'clock.

Respectfully submitted,

K. H. AIMO, *Clerk.*

Membership Cards.

Any member desiring a membership card may secure it by applying to the Secretary.

LIST OF MEMBERS.

ADDITIONS.

Chiesa, Ovidio D. .... 43 Rodman St., Quincy, Mass.
Randlett, Frederick J. .... 110 Blue Hill Ave., Roxbury, Mass.

CHANGES OF ADDRESS.

Cameron, Edward H. .... 44 Spring St., Somerville, Mass.
Carter, Clarence E. .... P.O. Box 174, Plattsburg, N. Y.
Connor, Bernard D. .... 15 Pennsylvania Ave., Somerville, Mass.
Hogue, Chester J. .... 3851 Grand Central Terminal, New York, N. Y.
Leland, Franklin E. .... 50 Maple St., Auburndale 66, Mass.
Tosi, Joseph A. .... 173 King Philip Rd., Worcester, Mass.
Whitmore, Harold C. ... Care Stone & Webster, Flat Rock, Wayne County, Mich.
Williams, A. K. .... 143 Newbury St., Roslindale, Mass.

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Water Supply Paper. No. 487.

Municipal Reports.

Boston, Mass. Annual Report Finance Commission. 1921.

Cambridge, Mass. Annual Report Water Department. 1920.

Concord, N. H. Annual Report Board of Water Commissioners. 1921.

New Bedford, Mass. Annual Report Water Board. 1921.

North Adams, Mass. Annual Report City. 1921.

Philadelphia Pa. Annual Report Water Supply Problem.

1922.

Springfield, Mass. Annual Report Municipal Water Works. 1921.

State Reports.

Massachusetts. Industrial Review, No. 7, 1922.

Miscellaneous.

Collapsing Pressures of Lap-Welded Steel Tubes. R. D. Stewart.

Handbook for Highway Engineers. Harger & Bonney. 1919.

LIBRARY COMMITTEE.

Vol. IX SEPTEMBER, 1922 No. 7

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"Rehabilitation of Street Railway Tracks." By Frank B. Walker.

Memoir of Deceased Member.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETING.

BOSTON, September 20, 1922. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 7.45 P.M. by the President, Prof. Dugald C. Jackson. There were 60 members and guests present.

The minutes of the meeting of May 17 were read and approved, as printed in the June JOURNAL.

The Secretary reported for the Board of Government the names of those elected to membership in the grade of Member:

Members — Messrs. George F. McCann and Harry A. Hageman.

On motion of R. S. Weston, it was voted unanimously that the Board of Government be authorized to use the income from the Permanent Fund to meet current expenses to such an extent as they deemed necessary.

The President announced the appointment of Prof. C. Frank Allen as the representative of the Boston Society of Civil Engineers on the Zoning Advisory Commission of the City of Boston.

Announcement was made of the appointment by the Board of Government of Charles R. Gow as the representative of this Society on American Engineering Council for the year beginning January 1, 1923.

The President spoke of the recent meeting of the Executive Board of American Engineering Council held in Boston on September 8 and 9, and described the part taken by this Society in connection with the dinner tendered to the visiting members of the Executive Board.

Prof. Jackson spoke briefly of the social gatherings held in the Society's rooms in advance of the regular meetings, urging the members to come and partake of the refreshments and meet their fellow members.

The subject of the meeting, " Rehabilitation of Street Railway Tracks," was presented by Frank B. Walker, Chief Engineer, Eastern Massachusetts Street Railway Company. This paper, illustrated with slides, furnished an interesting account of the recent rehabilitation work carried out by the Eastern Massachusetts Railway both on its unpaved country tracks and on the paved city tracks.

A motion picture, showing the construction of track, making use of modern labor saving devices, was exhibited through the courtesy of the Boston Elevated Railway Co.

After considerable discussion of the subject by members and by guests from New England street railways, the meeting adjourned at 10 P.M.

J. B. BABCOCK, *Secretary.*

JUNE EXCURSION.

THE annual outing of the Boston Society of Civil Engineers was held on Wednesday, June 14, 1922, and included an inspection trip to some of the fortifications of Boston Harbor and a shore dinner at Pemberton. A bright, sunny day, the only

one in a period of two weeks, brought out a record-breaking crowd of 160 members and guests and provided ideal conditions for the outing.

Through the courtesy of Brig.-Gen. Mark L. Hersey, commanding officer of the First Corps and Coast Artillery, the inspection trip was made on an Army boat of ample size. The party gathered at the Army Supply Base, South Boston, and left at 1.30 P.M., Gen. Hersey himself being on hand to see that all arrangements were complete. A stop was made at Fort Strong, on Long Island, where Col. Geary, commanding officer of the Boston Harbor defences, came on board to personally conduct the inspection.

The first landing was made at Fort Warren, on George's Island. Here were seen the parade grounds and barracks, the magazines and the mine storehouses. The feature of the inspection was the tripping into battery of a 10-inch disappearing gun by a gun crew while Col. Geary and his aides explained the operation.

At Hog Island, the next stop, the party was met by Lieut.-Col. Willing, of the Corps of Engineers, who is in charge of the construction of fortifications of the very latest type at that point. He conducted the party over the entire plant, including the massive concrete gun implacements and the magazines and barracks protected by thick layers of concrete, steel, and sand.

With the inspection concluded, the boat stopped to let the party go ashore at Pemberton. With appetites whetted by the afternoon's exercise in the open the members and their guests gathered in Pemberton Inn and did full justice to the shore dinner there prepared for them. Following the dinner a baseball game was to have been played between the Designers Section and the Sanitary Section; but it was deserted in the rush for the homeward bound Nantasket steamer.

The thanks of the Society are due the Army officers whose hospitality and generosity contributed so largely to the success of the outing.

ERWIN HARSCH,
Chairman, Committee on Social Activities.

APPLICATIONS FOR MEMBERSHIP.

[September 15, 1922.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

DREW, SAMUEL TILDEN, Quincy, Mass. (Age 24, b. Wollaston, Mass.) Graduated from Mass. Institute of Technology in 1921, since which time he has been in the employ of Metcalf & Eddy as assistant engineer. Refers to S. Keith, F. A. Marston, C. W. Rolfe, A. L. Shaw, C. M. Spofford and H. C. Thomas.

SWEET, HERBERT A., Allston, Mass. (Age 32, b. Bridgewater, Mass.) Graduated from Mass. Institute of Technology in 1914 with degree of B. S. in civil engineering. From 1915-16 was bridge inspector and structural engineer on the B. & M. R. R.; 1917–22 engaged in insurance engineering, largely structural engineering, except for five months in field artillery officers' training school at Camp Dix. At present with the Associated Factory Mutual Fire Insurance Co. Refers to H. L. Carter, J. O. DeWolf, G. L. Hosmer, G. E. Russell and C. M. Spofford.

LIST OF MEMBERS.

CHANGES OF ADDRESS.

BATEMAN, LUTHER H. .... 420 State House, Boston, Mass.
CHISHOLM, HENRY .... 19 Chester Rd., Belmont, Mass.
COWLES, M. W. .... 82 Mill Plain Rd., Fairfield, Conn.
FAIR, GORDON M. ... 112 Pierce Hall, Harvard University, Cambridge, Mass.
HERING, RUDOLPH .... 1 West 70th St., New York, N. Y.
KLINK, N. S. .... Rm. 636, Little Bldg., 80 Boylston St., Boston, Mass.
O'BRIEN, M. J. .... Lockwood, Greene & Co., Piedmont Bldg., Charlotte, N. C.
ROSE, BERNARD S. .... c/o C. T. Main, 200 Devonshire St., Boston, Mass.
SMITH, SIDNEY .... Scituate, Mass.
SYMONDS, HENRY A. .... 68 Devonshire St., Boston, Mass.
VAN DER PYL, EDWARD .... Holden, Mass.
YOUNG, ERVING M. .... 100 Gibbs St., Rochester, N. Y.

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Birth Statistics of United States, 1920.
Bulletins 1031 and 1050, U. S. Dept. of Agriculture.
Sitka Spruce, U. S. Dept. of Agriculture.
Statistics of Railways in United States. 1919.
Water Supply Paper No. 500.

State Reports.

Massachusetts. Annual Report Department of Public Utilities. 1921.

Massachusetts. Annual Report Division Housing and Town Planning.

Massachusetts. Report of Joint Board of Health & Metropolitan District Commission. 1921.

New York. Report of Public Service Commission. 1918, Vol. 2., and 1919, Vol. 1.

Municipal Reports.

Bangor, Me. Annual Report of Water Board. 1921.

Chelsea, Mass. Annual Report Water Commissioner. 1921.

Fall River, Mass. Annual Report City Engineer. 1921.

Melrose, Mass. Annual Report Public Works Department. 1921.

New Bedford, Mass. Annual Report Engineering Department. 1921.

New Orleans, La. Annual Report Sewerage and Water Board. 1921.

Providence, R. I. Annual Report Department of Public Works. 1921.

Providence, R. I. Annual Report City Engineer. 1921.

Reading, Pa. Annual Report Bureau of Water. 1921.

St. Louis, Mo. Annual Report Water commissioner. 1921.

St. Paul, Minn. Annual Report Board of Water Commissioners. 1921.

Taunton, Mass. Annual Report Water Commissioners. 1921.

Waltham, Mass. Annual Report Department of Public Works. 1921.

Worcester, Mass. Annual Report Superintendent of Sewers. 1921.

Miscellaneous.

Barium and Strontium in Canada.

Construction Contracts. Springfield-W. Springfield Bridge. Gift of Fay, Spofford & Thorndike.

Dedication of Hampden County Memorial Bridge. Gift of Fay, Spofford & Thorndike.

John Fritz Medal. 1922.

Mexican Petroleum. Pan-American Petroleum & Transport Co.

Proceedings Amer. Soc. Municipal Improvement. 1921.

Theory of Structures. Charles M. Spofford.

Wood Preserving Terms. E. F. Hartman & E. F. Paddock.

LIBRARY COMMITTEE.

Vol. IX · OCTOBER, 1922 No. 8

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPER IN THIS NUMBER.

Report of the Committee on Run-Off.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETING.

BOSTON, October 4, 1922.—The Sanitary Section of the Boston Society of Civil Engineers held a meeting this evening in the Society Rooms, Tremont Temple. The meeting was called to order at 7.45 P. M. by the Chairman, Arthur D. Weston.

In the absence of the Clerk, John P. Wentworth was elected Clerk pro tem.

The Chairman announced that the Executive Committee had elected Frank L. Flood to membership.

The Chairman introduced Prof. George C. Whipple, who presented a paper on "Mosquito Control in Massachusetts." The paper was followed by a description of the different species of mosquitoes by Prof. C. T. Brues, of Harvard University. The subject was discussed by Messrs. Chase, Porter, Marston and Dorr.

A moving picture film entitled "The Mosquito and the Flea" was shown.

On motion of Mr. Marston, it was voted: That the Executive Committee be requested to direct a communication to the Affiliation Council with the request that a Committee be appointed to consider the question of mosquito extermination and to coöperate with the Anti-Mosquito League.

On motion of Mr. Fales, a rising vote of thanks was given to Prof. Whipple and Prof. Brues for their courtesy in speaking to the Section.

Members and guests present 51. The meeting adjourned at 9.45 P. M.

JOHN P. WENTWORTH, *Clerk pro tem.*

APPLICATIONS FOR MEMBERSHIP.

[October 15, 1922.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Chase, Edward Sherman, West Newton, Mass. (Age 38, b. Merrimac, Mass.) Graduate of Mass. Inst. Tech. in Sanitary Engineering, 1907. Was a rodman during summer of 1905; topographic draftsman in summer of 1906; chemist, bacteriologist 1908-9; chemist in charge, sewerage purification, 1909-13; assistant engineer, state department of health, 1913-20; sanitary engineer, 1920 to date. Refers to H. P. Eddy, F. A. Marston, L. Metcalf, A. L. Shaw, J. P. Wentworth and A. D. Weston.

Fessenden, Howard Pike, Newton Centre, Mass. (Age 31, b. Newton Centre, Mass.) Graduate of Massachusetts Institute of Technology in 1913. Has been draftsman, designer, squad chief, assistant engineer and junior engineer with Stone & Webster, Inc., from 1913 to date. Refers to L. S. Cowles, E. P. Lane, J. H. Manning, C. E. Nichols, D. M. Wood.

Glynn, Thomas P., Boston, Mass. (Age 50, b. Boston, Mass.) Educated in the Boston English High School and Northeastern College School of Law. Learned the trade of brick and stone masonry and served as foremen, superintendent, estimator and general contractor on all kinds of building construction. He has held the position of sewer inspector, schoolhouse inspector, and for seven years was chief of department of alterations and repairs in schoolhouse department. Is now chairman of the Schoolhouse Commissioners of the City of Boston. Refers to J. E. Carty, G. W. Dakin, E. S. Dorr, C. S. Drake, J. E. L. Monaghan and H. L. Patterson.

Moreland, Edward L., Brookline, Mass. (Age 37, b. Lexington, Va.) Graduate of Johns Hopkins University, Mathematical-Physical course; and of Massachusetts Institute of Technology, Electrical Engineering course. He is a Fellow of the American Institute of Electrical Engineers, a member of American Society of Mechanical Engineers, Was assistant engineer with D. C. and Wm. B. Jackson, 1908-1912; manager Boston office 1912-1915; partner 1916-1918; Captain and Major, Engineers Corps, U. S. Army, 1918-1919; and partner and manager of Jackson & Moreland 1919 to date. Refers to F. H. Fay, C. R. Gow, F. M. Gunby and D. C. Jackson.

Thoron, Benjamin Warder, Danvers, Mass. (Age 25, b. Washington, D. C.) Graduated from Harvard College 1918, Mass. Inst. Tech., in civil engineering, 1922. Is a draftsman in the office of Fay, Spofford & Thorndike. Refers to C. R. Berry, E. Harsch, R. W. Horne, H. A. Gray, W. F. Pike, C. M. Spofford.

Winslow, Earl Holden, Norwood, Mass. (Age 24, b. Westboro, Mass.) Graduate of Worcester Polytechnic Institute with degree of B. S. in chemistry in June, 1921. Was in the army from July 27 to Dec. 20, 1918. Most of 1919 was employed in the laboratory of the General Electric Co. at the Pittsfield Works; where he was assistant in metallurgical research; during the summer of 1920 was employed at the North Works of the American Steel & Wire Co., Worcester, as a wire cutter and gager; in June, 1921 entered the employ of Metcalf & Eddy as a sanitary engineer, and is still in their employ. Refers to S. E. Coburn, H. P. Eddy, A. L. Fales, A. L. Maddox and J. P. Wentworth.

LIST OF MEMBERS.

CHANGES OF ADDRESS.

CASEY, JOHN J. . . . . 116 Tonawanda St., Dorchester, Mass.
COOPER, CHARLES S. . . . . 147 Talbot Ave., Dorchester, Mass.
DEPUY, CLARENCE S. . . . . 1431 University Ave., New York, N. Y.
GAMMAGE, ARTHUR L. . . . . 14 Beacon Street, Boston, Mass.
GIBSON, FREDERICK M. . . . . 47 Granite St., So. Boston, Mass.
HALEY, F. WILLIAM . . . . 58 Wales Place, Dorchester, Mass.
LUCAS, JOHN . . . . 12 Powell Ave., East Lynn, Mass.
LUTHER, HOWARD B. . . . . . Civil Engineering Dept., University of Cincinnati, Cincinnati, O.
MOULTON, J. WENDELL, ... 219 East 17th St., New York, N. Y.
REYNOLDS, KENNETH C. . . . . Mass Inst. Tech., Cambridge, Mass.
ROCKWELL, EDWARD H. . . . . Dean of Engineering, Rutgers College, New Brunswick, N. J.
ROLFE, CLARENCE W. . . . . c/o Metcalf & Eddy, 14 Beacon St., Boston, Mass,
SARGENT, F. C. . . . c/o C. H. Tenney & Co., 200 Devonshire St., Boston, Mass.
STAFFORD, EARL . . . . 433 Munsey Bldg., Washington, D C.
THORPE, LEWIS D. . . . . 200 Devonshire St., Boston, Mass

DEATH.

MORSE, WILLIAM F . . . . September. 15, 1922

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Bureau of Civil Service. Report to Governor-General of Philippine Islands. 1921.

Census of United States. Vol. 3, Vol. 6, Parts 1, 2 and 3. 1920.

Census of United States. (Massachusetts, Manufactures.) 1919.

Water Supply Papers, Nos. 463 and 478.

State Reports.

Massachusetts. Industrial Review, No. 8.

Municipal Reports.

Brockton, Mass. Annual Report Water Commissioners. 1921.

Erie, Pa., Annual Report Water Works. 1921.

Marlboro, Mass. Annual Report Water and Sewage Commissioners. 1921.

Newton, Mass. Annual Report City Engineer. 1920 and 1921.

New York, N. Y. Annual Report Board of Water Supply. 1921.

New York, N. Y. Annual Report President Borough of Manhattan. 1921.

North Andover, Mass. Annual Report Board of Public Works. 1921.

Miscellaneous.

Report on Structural Materials along St. Lawrence River between Prescott, Ont., and Lachine, Quebec. Dept. of Mines Canada.

LIBRARY COMMITTEE.

Vol. IX NOVEMBER, 1922 No. 9

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"Construction of a Pre-Cast Concrete Slab Bridge at Central St., Lowell." By S. Stanley Kent.

"Strengthening Old Bridges." By Lewis E. Moore.

"A Long Span Reinforced Concrete Girder Bridge at Cohasset Narrows." By B. A. Rich.

"Mosquito Control in Massachusetts." By George C. Whipple.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETING.

BOSTON, October 18, 1922. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 7.45 P. M., by the President, Professor Dugald C. Jackson. There were 110 members and guests present.

The minutes of the meeting of September 20 were approved as printed in the September JOURNAL.

The Secretary reported for the Board of Government the names of those elected to membership: Herbert A. Sweet, grade of Member; Samuel T. Drew, grade of Junior.

The President announced the death of William F. Morse on September 15. It was voted that a committee of two be appointed by the President to prepare a memoir of Mr. Morse.

The President announced the death of Hon. John N. Cole, Commissioner of Public Works. Although not a member of the Society, Mr. Cole presented an interesting paper on Massachusetts Highways at a meeting on February 28, 1922.

It was voted unanimously that the Board of Government be authorized to use the income from the Permanent Fund for the current year to such an extent as they deem necessary in payment of the current expenses of the Society. This vote had been passed at the September meeting and in accordance with the By-Laws an affirmative vote of two-thirds at two successive regular meetings is required to make an appropriation from the Permanent Fund.

The first meeting of The Affiliated Technical Societies of Boston is to be held Thursday, November 23, 1922, on the subject of "Commercial Aviation — The Present State of the Art — with Special Reference to the Development of Boston as an Air Port." It was voted that the Society omit the regular November meeting in order to promote greater interest and attendance at the Affiliation meeting on November 23.

Professor Jackson announced that Frank A. Barbour, President of The New England Water Works Association, had extended a cordial invitation to the members of the BOSTON SOCIETY OF CIVIL ENGINEERS to attend a luncheon meeting of that society at the City Club on Tuesday, November 14. The program, which will be of unusual interest, is as follows: "Some Engineering Aspects of Cast Iron" by Dr. Richard Moldenke, Watchung, N. J.; "Tars, New and Old" by S. R. Church, Chemist and Manager of Oil and Tar Division, The Barrett Company, New York, N. Y., and moving pictures of the Centrifugal Process of Casting Pipe taken at the new plant of the United States Cast Iron Pipe & Foundry Co., Birmingham, Ala.

The program of the meeting was a "Symposium on Bridges," and the first paper presented was "Construction of a Pre-Cast Slab Bridge at Central Street, Lowell," by S. Stanley Kent, Assistant Engineer, Proprietors of Locks and Canals, Lowell, Mass.

Lewis E. Moore, Consulting Engineer, Boston, formerly connected with the Department of Public Utilities of Massachusetts, discussed the topic "Strengthening of Old Bridges." A paper entitled, "A Long Span Reinforced Concrete Girder Bridge at Cohasset Narrows," was presented by Barzillai A. Rich, of Fay, Spofford & Thorndike, Consulting Engineers, Boston.

The original program included "A Survey of Massachusetts Bridges" by W. F. Williams, Bridge Engineer, Department of Public Works, but on account of the death of Hon. John N. Cole, Commissioner of Public Works, on the day of the meeting, Mr. Williams did not present the paper at this time.

After an interesting discussion of these papers, all of which were illustrated by slides, the meeting adjourned at 10.15 P.M.

J. B. BABCOCK, *Secretary.*

APPLICATIONS FOR MEMBERSHIP.

[November 23, 1922.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

ALCOTT, WILLIAM JEFFERSON, Jr., Watertown, Mass. (Age 28, b. Chelsea, Mass.) Attended Mass. Argricultural College two years. From August 1915-January 1916 was a transitman with the Rhode Island Co. of Providence, R. I.; from January 1916 to June 1917 was a rodman with N. Y., N. H. & H. R. R. at New London, Conn.; with the 101st Engineers from June 1917 to May 1919; from June 1919 to September, same year, was inspector on the N. Y., N. H., & H. R. R., also from June 1920 to September of same year; entered Tufts College in the fall of 1919 and graduated in 1922 with B.S. in civil engineering; during the summers of 1921 and 1922 was assistant engineer in the Massachusetts Highway Commission, and in November 1922 became draftsman on the B. & M. R. R. where he is at present employed. Refers to H. C. Archibald, B. W. Guppy, P. Jones and F. C. Shepherd.

ARMINGTON, EVERETT ALLAN, Everett, Mass. (Age 29, b. Weymouth, Mass.) From 1910 to 1918 engaged in highway engineering with the Massachusetts Highway Commission; 1918-1919 draftsman with the B. & A. R. R.; 1919-1920 draftsman and designer with Stone & Webster, Inc.; 1921-1922 cost work with the B. & M. R. R.; and at present structural draftsman with B. & M. R. R. Graduate of High School, and two years at Northeastern University, also took correspondence courses with Massachusetts Board of Education and University of Michigan. Refers to H. C. Archibald, L. G. Brackett, P. Jones and F. C. Shepherd.

BAKER, RALPH EDMUND, Medford, Mass. (Age 34, b. Joliet, Ill.) Graduate of the Manchester High School and of Dartmouth College, also of Thayer School of Civil Engineering. From 1913-1914 was assistant resident engineer with French & Hubbard; from February, 1914-October, same year, detailing reinforced steel; from October, 1914- March, 1916 with B. & M. R. R. as bridge and building inspector under B. W. Guppy; 1916-1917 engineering draftsman, designing five story reinforced factory building, and other large buildings; 1918 assisted in supervising and inspecting a large factory plant in Erie, Pa.; September, 1918-July, 1922 was employed at the U. S. Naval Ordnance Plant, S. Charleston, W. Va., as engineering draftsman; from September 1922 to date with F. O. Lewis as engineer on proposed new office building. Refers to B. W. Guppy, H. S. Knowlton, W. D. Trask, R. E. Whitney, R. Whitman and J. F. Wilber.

BARTLETT, JOSEPH H. Jr., Quincy, Mass. (Age 18, b. Brooklyn, N.Y.) Graduate of Quincy High School 1920. Is now a Junior at Northeastern University. Was a rodman with Ernest W. Branch for seven weeks and with Aspinwall & Lincoln to date. Refers to H. B. Alvord, E. W. Branch, C. S. Ell, J. W. Ingalls, E. H. Lincoln and G. H. Newcomb.

BROWN, HOWARD LESLIE, Medford, Mass. (Age 26, b. Brockton, Mass.) Graduate of Wentworth Institute, architectural construction and engineering course; Franklin Union evening school one winter, also took course in surveying at Tufts College. Employed by Boston & Maine R. R. in office of Engineer of Structures from May 1919 to the present time. Refers to H. C. Archibald, B. W. Guppy, P. Jones, A. W. Knowlton, D. N. Peasley.

BURKE, JOHN JOSEPH, Boston, Mass. (Age 34, b. Boston, Mass.) Graduate of Mechanic Arts High School, also attended Franklin Union evening classes 1915-1917. From 1907-1910 was a rodman; 1910-1914 was a transitman; 1915 to the present time has been in charge of engineering party in Sewer Department, City of Boston. Refers to F. J. Gately, G. W. Hamilton, W. A. Johnson and J. E. L. Moneghan.

BURROUGHS, JOHN HENRY, Dorchester, Mass. (Age 49, b. Bridgeport, Conn.) Educated in the Boston public schools and English High. Started engineering with Charles F. Baxter, in 1895 and with the City of Boston 1896; Has been in the Street Commissioner's Department, Surveying Division from 1896 to the present time. Is now assistant engineer in Street Laying Out Department. Refers to N. J. Holland, H. C. Mildram, J. E. L. Monaghan, L. J. Monahan and E. H. Rogers.

CADIGAN, DANIEL J., Boston, Mass. (Age 40, b. Boston, Mass.) Educated in the Boston schools. Became rodman for City of Boston from 1910-1917; transitman 1917-1922 with the City where he is at the present time. Refers to J. E. Brosnahan, G. W. Dakin, E. S. Dorr, C. S. Drake, F. A. Garvin and J. E. L. Monaghan.

CARROLL, CHARLES CHRISTIAN, Boston, Mass. (Age 53, b. Boston, Mass.) Educated in the public schools of Boston, Ottawa University of Canada and Lowell Institute Course 1906-1908. Was rodman and then transitman for City of Boston 1887-1898; draftsman 1898-1906; draftsman with State of Massachusetts 1906-1908; assistant engineer, City of Boston, 1908-1920; chief engineer, Universal Tide Power Co., 1920-1922; and at present is draftsman and engineering inspector in the Sewer Service, City of Boston. Refers to G. W. Dakin, E. S. Dorr,F. A. Lovejoy, D. J. Lynch and J. E. L. Monaghan.

CARROLL, WILLIAM N., Dorchester, Mass. (Age 42, b. Boston, Mass.) Educated in the Boston schools. Worked with Metropolitan Park Commission as rodman 1897-1900; as transitman with City of Boston, 1900-1907; assistant engineer, City of Boston, 1907-1922; is at present assistant in the Street Laying Out Department. Refers to A. J. Howland, H. C. Mildram, J. E. L. Monaghan, L. J. Monahan and F. O. Whitney.

CHUBBUCK, HIRAM R., Dorchester, Mass. (Age 53, b. Roxbury, Mass.) He has been employed in the Highway Department since 1891 and at present is assistant engineer in the Highway Division of Public Works Department, City of Boston. Refers to B. F. Bates, J. E. Carty, M. T. Cook, C. S. Drake A. E. Haskell and F. P. Spalding.

COHEN, SAMPSON KALMON, Roxbury, Mass. (Age 34, b. Poland.) Educated in the public schools of Boston and a graduate of Mass. Inst. Tech. in 1910. From 1910-1911 he was a tracer and detailer with a bridge company; 1911-1913 a checker of shop drawings; 1913-1914 a structural draftsman on the Isthmian Canal; 1914-1916 chief draftsman, Bridge Division, Missouri Pacific R. R.; 1916-1917 chief bridge designer B. & M. R.R.; 1917-1919 with the 101st Engineers; 1919 to the present employed in the office of Engineer of Structures B. & M. R. R. Refers to H. C. Archibald, B. W. Guppy, P. Jones and C. M. Spofford.

DONNELLY, WILLIAM FRANCIS, Boston, Mass. (Age 28, b. Boston.) A graduate of Wentworth Institute. From 1914-1917 he was employed on Water Service, City of Boston, as a rodman; 1917 to date was transitman in the same service. Refers to C. J. Carven, F. A. McInnes, J. McNulty, J. E. L. Monaghan, D. J. Sullivan and F. I. Winslow.

FITZGERALD, THOMAS J., Boston, Mass. (Age 42, b. Boston, Mass.) He entered the employ of the City of Boston after graduating from the Boston English High School. He began work with the Engineering Department of the City of Boston; also served in the Bridge Division until 1922 when he was transferred to the Highway. Refers to J. E. Carty, M. T. Cook, R. N. Cutter, B. F. Bates, E. H. Howe and F. P. Spalding.

FLYNN, LAWRENCE R., Boston, Mass. (Age 54, b. Ireland). Was educated in Ireland. Was principal teacher of mathematics in the Dublin Model School 1894-1902; held the same position in the Boardman Advanced Evening School in New Haven, Conn., 1903-1911 inclusive; was private secretary to assistant treasurer to the Comptroller of State of Connecticut 1912-1915; with the City of Boston since August 1916 as rodman, provisional draftsman and instrumentman, and now in the Sewer Service. Refers to T. F. Bowes, G. W. Dakin, E. S. Dorr, C. S. Drake, F. S. Lovejoy, and J. E. L. Monaghan.

GARNEY, EMERY W., Bridgewater, Mass. (Age 21, b. Bridgewater, Mass.) Graduated from the Bridgewater High School and then spent two years at Northeastern University during which time he has spent about forty-six weeks in school and fifty weeks at engineering practice; has had experience as rodman, transitman, timekeeper, and is now beginning his junior year at Northeastern University. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls and W. E. Nightingale.

HOISINGTON, EDWIN T., West Roxbury, Mass. (Age 50, b. Hartland, Vt.) Had three years at Mass. Inst. Tech. He was with the City of Boston as rodman and instrumentman and assistant engineer up to date. Refers to B. F. Bates, F. H. Fay, A. E. Haskell, A. Howland, J. E. L. Monaghan and J. H. Sullivan.

HUNT, ARTHUR WILLIAM, Boston, Mass. (Age 47, b. Boston, Mass.) Educated in the Boston public schools and English High. Was a rodman in the City Engineer's office 1891-1892; rodman with the Old Colony 1893; rodman and transitman with City Engineer, Boston, 1894-1898; transitman and draftsman 1898-1911; draftsman and assistant engineer, Highway Division, Public Works Department, City of Boston, 1911-1916; and assistant engineer in the same department, in charge of field party on street construction from 1916 to date. Refers to B. F. Bates, F. H. Fay, A. E. Haskell, J. E. L. Monaghan, C. G. Norris and J. H. Sullivan.

KELLY, THOMAS, Jamaica Plain, Mass. (Age 31, b. Roxbury, Mass.) He was a rodman in the Sewer Service, City of Boston, 1911-1916; since this time he has been transitman in the same department. Refers to J. E. Carty E. S. Dorr, C. S. Drake, W. V. P. Hoar, D. P. Kelley and J. E. L. Monaghan.

KENNEY, THOMAS B., Boston, Mass. (Age 33, b. Boston.) Educated in the Boston schools; graduate of Northeastern University in civil engineering. From 1911-1912 was rodman in Sewer Service; 1912-1917 transitman and in charge of party; 1917-1921 transitman in Street Laying Out Department; a part of 1921 assistant engineer in the Highway Division, Public Works Department of Mass.; since which time he has been in the Street Laying Out Department as transitman and at the present time is engineer for the Assessing Department of City of Boston. Refers to T. F. Bowes, C. S. Drake, W. E. Hannan, D. P. Kelley, J. E. L. Monaghan, and F. O. Whitney.

LENNON, ARTHUR J., Boston, Mass. (Age 34, b. Boston.) Educated in the public schools of Boston. Two years at Mass. Inst. Tech., chemical engineering course, and two years at Lowell Institute, building course. He was rodman in the sewer service 1910-1912, transitman 1912-1919; and is at the present time employed in the same service. Refers to G. W. Hamilton, W. A. Johnson, J. E. L. Monaghan, E. F. Murphy and L. B. Reilly.

LIDDELL, WILLIAM ANDREW, Lowell, Mass. (Age 28, b. Lowell, Mass.) Graduated from Mass. Inst. Tech. in civil engineering 1916. Returned to the Institute as assistant in civil engineering for the following year. From August 1917-October 1918 with American Tel. & Tel. in New York, with the exception of eight months in the army. In October 1919 returned to Mass. Inst. Tech, as instructor in civil engineering covering surveying, hydraulics and hydraulic problems. During spare time he has been connected with the Locks and Canals of Lowell, with Fay, Spofford & Thorndike and H. K. Barrows, Consulting Engineers, and City Planning Board; and at the present date is still instructor at Technology. Refers to H. K. Barrows, D. Porter, A. T. Safford and C. M. Spofford.

McCARTY, FRANK P., Roxbury, Mass. (Age 48, b. Roxbury, Mass.) Graduate of Roxbury High School; a law student from 1892-95; His experience has been as follows: rodman 1895-98; transitman from 1898 to the present time; is now in the Laying Out Department as transitman. Refers to N. J. Holland, H. C. Mildram, J. E. L. Monaghan, and F. O. Whitney.

MOFFIE, SAUL E., Winthrop, Mass. (Age 25, b. Boston, Mass.) Attended Franklin Union where he took civil engineering course, also took civil engineering at Tufts College where he received degree B.S. During the summer of 1920 employed by Lockwood, Greene & Co., tracing and detailing; during the summer of 1922 was draftsman with Lamson Co.; and at present is employed as structural draftsman, with the Boston & Maine R. R. Refers to H. C. Archibald, B. W. Guppy, P. Jones and F. C. Shepherd.

MOULTON, EDWARD L., Mattapan, Mass. (Age 55, b. Dorchester, Mass.) Educated in the Boston public schools. He was transitman with Whitman & Breck, 1885-1886; transitman, City Surveyor's office, 1887-1892; assistant engineer in charge of party Street Laying Out Department 1892–1916; assistant engineer in charge of department (Street Laying Out Department.) 1916 to date. Refers to F. M. Miner, H. C. Mildram, F. O. Whitney and C. S. Drake.

MURPHY, FREDERICK FRANCIS, Boston, Mass. (Age 40, b. Boston, Mass.) Educated in the schools of Boston and took a course at Y.M.C.A. He entered City service 1897 as office boy and was promoted, after examination, to the position of rodman and then as senior draftsman and at the present time is designing draftsman in Engineering Division of Street Laying Out Department. Refers to A. Howland, H. C. Mildram, F. M. Miner, H. L. Patterson and F. O. Whitney.

MURRAY, JAMES SAUNDERS, Boston, Mass. (Age 49, b. Boston, Mass.) Educated in the Boston public schools, Y.M.C.A. and International Correspondence School. He entered the employ of the City of Boston as rodman in Street Laying Out Department 1896; was appointed transitman July 1906 and has been in this department ever since. Refers to A. Howland, H. C. Mildram, F. M. Miner, H. L. Patterson and F. O. Whitney.

NOYES, JOHN H. L., Boston, Mass. (Age 43, b. Boston, Mass.) Studied at Boston College 1894-1897 and privately later. He entered the employ of the City of Boston in 1897 as rodman and worked up to junior engineer; carried on private engineering evenings from 1902-1918. He is at present chairman of the Board of Street Commissioners of Boston. Refers to A. Howland, H. C. Mildram, L. J. Monahan and F. O. Whitney.

O'FARRELL, MICHAEL DENIS, Boston, Mass. (Age 50, b. Chicago, Ill.) Graduated from Holy Cross College 1891; then took a two years course in structures at Franklin Union. Was transitman and assistant engineer on Boston Board of Survey work under the Commission for fifteen years; at present is assistant engineer in the Street Laying Out Department. Refers to N. J. Holland, J. McNulty, J. E. L. Monaghan, L. J. Monahan and F. O. Whitney.

REED, ALONZO B., Boston, Mass. (Age 33, b. Lowell, Mass.) Educated in the public schools of Lowell and later took courses in mechanical engineering in I. C. Schools, also civil engineering in American School of Correspondence. Has held positions as draftsman and engineer constantly since 1906 and is at present practicing both mechanical and civil engineering. Refers to A. W. Benoit, F. M. Gunby, C. T. Main and W. F. Uhl.

RUSSELL, ELWYN LEWIS, Boston, Mass. (Age 55, b. Boston, Mass.) Educated in the public schools of Cambridge, and special courses in mechanical and free hand drawing, International Correspondence School. He was with Childs Machine Co. as mechanical draftsman 1885-1886; Boston Heating Co., 1887; general drafting with Walter S. Coffin, 1888; with Aspinwall & Lincoln 1889-1891; with City of Boston, Board of Survey, 1891-1895; Engineering Department 1895-1911; Street Laying Out Department 1911 to the present time. Refers to F. H. Fay, H. C. Mildram, J. E. L. Monaghan, L. J. Monahan and F. O. Whitney.

SCANNEL, RICHARD ALBERT, Dorchester, Mass. (Age 33, b. Hull, Mass.) Educated in the St. Augustin Academy in Hartford, Conn., St. Joseph's Academy at Wellesley Hills, also a college in New York City. From 1911 to 1917 he was a rodman in the Sewer Service of the City of Boston; 1917-1922 he has been, and is, instrumentman in the same division. Refers to

E. S. Dorr, C. S. Drake, G. F. Haskell, F. A. Lovejoy, J. E. L. Monaghan and E. F. Murphy.

SHERMAN, GEORGE HUTCHINSON, Boston, Mass. (Age 47, b. Auburndale, Mass.) Educated in the public schools of Lawrence, Mass., where he fitted for Tech. He spent two years in steam-fitting and machine shop work; 1896-1898 in the office of C. H. W. Wood, engineer and surveyor; in 1898 he held the position of transitman in the Engineering Division, City of Boston, where is still employed. Refers to E. S. Dorr, F. H. Fay, H. C. Mildram, F. M. Miner, E. H. Rogers and F. O. Whitney.

STAFFORD, ROLAND GROVER, Attleboro, Mass. (Age 35, b. Attleboro, Mass.) Graduate of Tufts College in structural engineering. Was draftsman with Stone & Webster, Inc., a part of 1914; in March 1915 he entered the employ of the Boston & Maine R. R. as assistant bridge inspector, in December of that year became bridge inspector on the Terminal Division and in July 1916 was transferred to office of Engineer of Structures as structural draftsman; from May 5, 1917 to August 15, 1919, served in the U. S. Army; September 1919 he returned to the Boston & Maine as structural draftsman where he is at present employed. Refers to H. C. Archibald, A. Q. Robinson, B. W. Guppy, P. Jones and A. W. Knowlton.

STEVENS, FRANK BURTON, Newton, Mass. (Age 28, b. Brookline, Mass.) Educated in the public schools, Phillips Exeter Academy, a year at Dartmouth College and a year at Mass. Inst. Tech. In 1915 to June, 1917 was instrumentman, inspector and assistant to resident engineer on construction of two coal handling plants; June, 1917 to April, 1919 with the U. S. Army; 1919-1920 general superintendent of building construction, with Leahy & Rattigan Construction Co.; from this time to September, 1922 with Haven & Hopkins as structural engineer. Refers to W. M. Bailey, H. K. Barrows, C. R. Gow, J. H. Libbey and W. A. Woods.

SULLIVAN, THOMAS F., Allston, Mass. (Age 52, b. Cambridge, Mass.) He has been employed in the Street Laying Out Department of the City of Boston as rodman and transitman and is at present filling the latter position in this department. Refers to A. Howland, H. C. Mildram, J. E. L. Monaghan, L. J. Monahan and F. O. Whitney.

SULLIVAN, WILLIAM JOHN, Boston, Mass. (Age 50, b. Boston, Mass.) Graduated from the Scituate High School in 1890 and entered at once the City Surveyor's office as rodman; passed examination as transitman in 1900 and as senior engineer in 1907; at the present time is assistant engineer in the Street Laying Out Department, City of Boston. Refers to C. H. Gannatt, A. Howland, E. H. Lincoln, H. C. Mildram, E. F. Murphy and F. O. Whitney.

WEEKS, LAWRENCE E., Malden, Mass. (Age 30, b. Everett, Mass.) Studied railroad engineering at Boston Y. M. C. A., structural engineering two years at Franklin Union, and took several years with the International Correspondence School. 1911-1912 was a rodman with Brookline Engineering Department; July 1912 – December 1916 was with Boston Transit Commission as rodman, transitman and draftsman; from September 1918

to the present structural draftsman with the Boston & Maine R. R. Refers to H. C. Archibald, R. B. Farwell, B. W. Guppy, P. Jones and L. B. Manley.

WHITMAN, KILBORN, JR., Boston, Mass. (Age 38, b. Boston, Mass.) Graduate of Mass. Inst. Tech. in 1905; 1905-1907 was assistant in the Civil Engineering Department at Tech.; 1907-1909 instrumentman and assistant engineer on water power and flood prevention for New York State Water Supply Commission; 1909-1914 was assistant engineer in the designing division of New York City Board of Water Supply, and in the filtration division of New York City Department of Water, Gas and Electricity; 1914-1916 held the same position with the Water Department of Cleveland, O.; 1916-1921 assistant designing engineer Hartford Board of Water Commissioners; is at present employed by Metcalf & Eddy. Refers to E. E. Pettee, C. M. Saville, J. P. Wentworth and L. P. Wood.

LIST OF MEMBERS.

ADDITIONS.

DREW, SAMUEL T.....................42 Bradford St., Quincy, Mass.
HAGEMAN, HARRY A.........................147 Milk St., Boston, Mass.

DEATHS.

BIDWELL, LAWSON B...............................November 19, 1922
COGGESHALL, R. C. P.............................October 20, 1922.

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Water Supply Papers 482 and 484.

State Reports.

Massachusetts. Report of Department of Public Health. 1920.

Wisconsin. Inland Lakes of Wisconsin. Wisconsin Geol. and Natural History Survey.

New York. Special Report on Municipal Accounts. State Comptroller.

Municipal Reports.

Fall River Mass. Annual Report Watuppa Water Board. 1921.

Medford, Mass. Annual Report Water and Sewer Commissioners. 1921.

New York, N. Y. Annual Report Bureau of Buildings. 1921.

Newton, Mass. Annual Report Street Department. 1921.

Northampton, Mass. Annual Reports City Officers, 1920 and 1921.

Miscellaneous.

Descriptive Geometry, Young & Baxter; Engines and Boilers, Thomas T. Eyre; River and Harbor Construction, Townsend, Gift of Dugal C. Jackson.

Shield and Compressed Air Tunneling, Hewett & Johannesson, Gift of McGraw-Hill Book Co.

Talc and Soapstone in Canada. Department of Mines, Canada.

LIBRARY COMMITTEE.

Vol. IX DECEMBER, 1922 No. 10

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

Commercial Aviation — the present State of the Art — with Special Reference to the Development of Boston as an Air Port.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

APPLICATIONS FOR MEMBERSHIP.

[December 20, 1922.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications

relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

BATES, RUFUS EDWARD, Quincy, Mass. (Age 25, b. Weymouth, Mass.) He is a graduate of Wentworth Institute, 1917, and served in the 101st Engineers from May, 1917, to September same year. With the exception of one year (March, 1921–March, 1922) he has been engaged in construction work for himself, also employed by the Hood Rubber Co. Is now with the Aberthaw Construction Co., both in the engineering department and outside. Refers to H. A. Gray, F. E. Leland, A. B. MacMillan and L. C. Wason.

CORBETT, JOHN VINCENT, Dorchester, Mass. (Age 40, b. Boston, Mass.) Educated in the Boston Public Schools and English High. Since 1901 he has been employed by the City of Boston, Highway Division, as rodman, transitman and assistant engineer in the construction of streets. Refers to B. F. Bates, G. W. Dakin, C. S. Drake, A. E. Haskell, J. E. L. Monaghan, T. Parker and J. H. Sullivan.

NICHOLS, HALL, Watertown, Mass. (Age 27, b. Clifton, Mass.) Technical education. In the service July 30, 1918, to January 25, 1919. On his discharge he returned to Mass. Institute Technology as assistant in Course 1 for one term; then worked for the Aberthaw Construction Co. until January, 1920, as job engineer; very shortly after this he went to the Holyoke Water Power Co., where he spent about three months in design work and then took charge of construction of an addition to their power plant; he is now with the Aberthaw Construction Co. in the engineering department doing design work. Refers to H. J. Hughes, A. B. MacMillan, J. W. Rollins, C. M. Spofford and G. F. Swain.

SMITH, SYDNEY, Cliftondale, Mass. (Age 22, b. Schenectady, N. Y.) Graduate of Tufts College, 1922, with degree B. S. in civil engineering. Is now a structural draftsman in Office of Structures, Boston & Maine R. R. Refers to H. C. Archibald, B. W. Guppy, P. Jones and E. H. Rockwell.

STALBIRD, JAMES AVERY, Swampscott, Mass. (Age 21, b. Boston, Mass.) Graduate of Mass. Institute of Technology, 1922. Since July, 1922, he has been with the State Department of Public Health. Refers to H. E. Holmes, G. A. Sampson, C. M. Spofford, A. D. Weston and E. Wright.

SULESKY, ADAM EDWARD, Somerville, Mass. (Age 23, b. Clinton, Mass.) Graduate of Tufts College, 1922. July 6, 1922, to Dec. 1, 1922, was with the State Highway Commission as engineer's assistant; is at present in the Structural Department of the Boston & Maine R. R., as a structural draftsman. Refers to R. Abbott, H. C. Archibald, B. W. Guppy, P. Jones and H. H. O'Connor.

LIST OF MEMBERS.

ADDITIONS.

CHASE. E. SHERMAN	14 Beacon St., Boston, Mass.
FESSENDEN, HOWARD P.	147 Milk St., Boston, Mass.
MORELAND, EDWARD L.	387 Washington St., Boston, Mass.
SWEET, HERBERT A.	65 Ashford St., Allston, Mass.
THORON, BENJAMIN A.	24 Holyoke St., Cambridge, Mass.
WINSLOW, EARL H.	15 Everett Ave., Norwood, Mass.

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Water Supply Papers Nos. 490-C and 490-D.
Bulletin 1077, U. S. Dept. of Agriculture.
Annual Report of Governor of the Panama Canal. 1922.

Municipal Reports.

Brockton, Mass. Annual Report of City Engineer. 1921.

Brockton, Mass. Annual Report of Sewerage Commission. 1921.

Brockton, Mass. Annual Report of Board of Survey. 1921.

Chicago, Ill. Proposed New Constitution for Illinois. By Chicago Bureau of Public Efficiency.

Chicago, Ill. Proposition to be voted on at special election, Dec. 12, 1922. C. B. of P. E.

Miscellaneous.

Handbook for Electrical Engineers. Harold Pender. Gift of Arthur H. Robbins, M. of A. I. E. E.

Transactions of American Society of Mechanical Engineers. 1921.

LIBRARY COMMITTEE.